THE AMERICAN GAS LIGHT JOURNAL

REDMAN&KENNY,N.Y.

PUBLISHING OFFICE No. 42 PINE STREET

DEVOTED TO THE INTERESTS OF ILLUMINATION, HEATING, MECHANICAL, CHEMICAL AND GENERAL SCIENCE.

VOLUME LXXIX. No. 2. Whole No. 1,466. | NEW YORK, MONDAY, JULY 13, 1903. | $3 PER ANNUM, IN ADVANCE.

A. M. CALLENDER & CO., Proprietors. C. E. SANDERSON, Manager. THOMAS J. CUNNINGHAM and ELBERT P. CALLENDER, Editors.

ENTERED AT THE POST OFFICE AT NEW YORK, N. Y., AS SECOND-CLASS MATTER.

Published on each Monday of the year, at No. 42 Pine Street, New York.

Telephone.—2996 John.

Terms of Subscription, Including Postage.—For the United States and Canada, $3 per annum. European countries, $5 (£1—25 francs). All payments to be made in advance. Single copies, 10 cents.

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The American News Company, Nos. 39 and 41 Chambers street, New York, are agents for this JOURNAL. Newsdealers will send orders to them.

Remittances should be made either by post office order, express money order, registered letter, or bank draft on New York, payable to the order of A. M. Callender & Co.

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Eleventh Annual Meeting, Pacific Coast Gas Association.

PACIFIC COAST GAS ASSOCIATION,
OFFICE OF THE SECRETARY,
SAN FRANCISCO, CAL., June 16, 1903.

The Eleventh Annual Meeting of the Pacific Coast Gas Association will be held in San Francisco, Cal., at the offices of the Pacific Gas Improvement Company, 455 Sutter street, Tuesday, Wednesday and Thursday, July 21st, 22d and 23d, 1903. The following papers will be read:

President's Address; by Mr. M. C. Osborn, San Francisco, Cal.

Wrought Pipe; by Mr. Franklin Riffle, San Francisco, Cal.

High Pressure Gas Distribution; by Mr. John A. Britton, Oakland, Cal.

Liquid Air: Its Application to the Gas Industry; by Prof. G. A. Bobrick, Los Angeles, Cal.

The Oil Industry of California from a Commercial Standpoint; by Dr. C. T. Deane, San Francisco, Cal.

Our Customers and Their Complaints; by Mr. D. Decker, Santa Rosa, Cal.

A Paper (subject to be announced later); by Mr. L. P. Lowe, San Francisco, Cal.

In addition to the above papers there will probably be contributions by at least two of the members on "Short Topics" of interest to the fraternity.

Arrangements have been made for a popular lecture on Liquid Air, by Prof. Bobrick, which will be given at the regular meeting place, Tuesday evening, July 21st, 1903. The lecture will be accompanied by experiments. It is the intention to make this lecture essentially a popular one, and members are cordially invited to bring their friends including ladies. Informality will be the order of the evening.

Wednesday evening, July 22d, will be the occasion of the annual banquet, to be held at Delmonico's, at which members only will be present.

On Thursday, July 23d, an all-day trolley car ride will be given and members will be conveyed by special cars to many points of scenic and historic interest in San Francisco and thereabout. An opportunity will also be afforded them to inspect at least one of the large power plants in the great Metropolis of the Pacific. Luncheon will be served at the Cliff House, and ample time will be allowed for a visit to Sutro baths (the largest in the world), or a stroll upon the beach. Following the usual custom, ladies will be welcome on the outing.

Through the courtesy of the Mechanics' Institute, arrangements have been made whereby the privileges of the Mechanics' Library, 33 Post street, are granted to all members of the Pacific Coast Gas Association during the period of its 11th annual meeting. Mr. J. M. Cummings, Secretary, acting for the Institute, extends to members a cordial invitation to make free use of the books and rooms of the Library, and will take pleasure in giving them any information or assisting them in any way in the use of the Library. It is hoped that members will show their appreciation by availing themselves of these privileges. No entrance tickets are required, but members will kindly wear the convention badge as a means of identification.

LIBRARY OF CONGRESS
JUL 13 1903

Members are strongly urged to lend their individual support to

The Wrinkle Department: Mr. Geo. H. Colquhoun, Fresno, Cal., Editor.

The Experience Department: Mr. R. P. Valentine, Sacramento, Cal., Editor.

The Novelty Department: Mr. Geo. H. Hollidge, Merced, Cal., Committee in charge.

The Wrinkle and Experience Departments depend for their very existence upon the willingness of members to contribute, and are an index of the "lag" or "lead" of the Association as a whole. Please remember this and help to maintain the standard.

The Novelty Department is, in truth, a novelty this year. In it we hope to find samples or models of all the good things manufactured during the past year for which a "gas man" has use. If you know of any, communicate immediately with Mr. Hollidge.

The Question Box.—An effort is being made this year to give the Question Box the attention which it merits, and to this end a special communication has been issued on the subject. An immediate reply thereto is requested.

The Secretary will be glad to meet members and furnish information, at any time prior to the meeting, at 628 Rialto Building, San Francisco, Cal.

J. B. GRIMWOOD, Secretary.

BRIEFLY TOLD.

"FIELD'S ANALYSIS."—A most welcome arrival this week was a copy of "Field's Analysis," which has to do with an analysis of the accounts of the principal gas undertakings in England, Scotland and Ireland for the year 1902. The present volume is the thirty-fourth that has been issued, and it is of a verity not only the equal but the superior of any of its predecessors, although the latter always teemed with information for the student or the engineer who would keep up with the actual, commercial standing and progress of the gas industry in Great Britain. Its compiler, Mr. John W. Field, is to be congratulated on the zeal, as well as on the success which has accompanied his labors, that has for its ending sets of tables and series of figures that are so plain that even a tyro in the profession may understandingly apply their meaning. We will be glad to furnish copies of this useful work, the price of which is $5.

NOTES——

AT the annual meeting of the Milwaukee (Wis.) Gas Light Company the officers elected were: Directors, Emerson McMillin, F. G. Bigelow, S. M. Green, H. C. Payne, J. P. Murphy, H. A. Leudke, G. G. Pabst, Edward G. Pratt and Wilmer Sieg; President, Emerson McMillin; First Vice-President and General Manager, Edward G. Pratt; Second Vice-President, S. M. Green; Chairman of the Board, F. G. Bigelow; Secretary and Treasurer, Ewald Haase; Asst. Secretary and Treasurer, S. J. Glass. From this list it will be noted that Mr. Edward G. Pratt, who some months ago was appointed General Manager of the Company, has also had put upon him the duties that go with the office of First Vice-President. That he will be thoroughly up to handling them efficiently goes without saying.

THE proprietors of the Cambridge (Mass.) Gas Company have awarded to the Western Gas Construction Company, of Fort Wayne, Ind., a contract for the placing of an 8-foot 6-inch set of the Western's extended carburetter and superheater design of water gas apparatus. The contract includes the operating floor complete. The apparatus will be ready for operation in November.

IT is reported that the United Gas Improvement Company will absorb the business and properties of the St. Paul (Minn.) Gas Light Company.

MR. J. H. CARDER has been appointed Assistant Superintendent of the Brooklyn Borough Gas Company, Coney Island, N. Y.

THE gentle, good and generous Mr. Claus Spreckels has sold his Independent Gas and Power Company and his Independent Electric Light Company, both of San Francisco, to the San Francisco Gas and Electric Company.

A CORRESPONDENT in Baltimore forwards the following under date of the 6th inst.: "A test case is to be arranged between the city and the Consolidated Gas Company as to the former's right to charge the latter a fee of 25 cents for each repaired gas meter which is resealed and restamped. The question at issue involves an annual amount of $4,000, which heretofore has been paid by the Gas Company to the city for the reinspection of repaired meters. Acting upon a recent opinion by Mr. W. Cabell Bruce, given before his appointment as City Solicitor, the Gas Company has taken the position that it is not obligated to pay other than the original charge for the meter inspection. Three-fourths of the meters inspected by the Superintendent of Lamps are of meters which have been taken out of service, repaired and put again in use."

Candles and Calories.

[A lecture delivered by PROF. VIVIAN B. LEWES, at the Annual General Meeting of the English Institution of Gas Engineers, held in London, June 9th, 10th and 11th.]

Candles and calories! True types of the past and future of the great gas industry—the dead past in which candle power was everything, the future in which calorific value and price will determine the position gas is to take in competition with other illuminants, not beeause the calorific value must be high to yield all the illumination required, but because fuel gas offers the widest field for expansion. The altered conditions of gas manufacture, brought about by the happenings of the past 10 years, demand an entire rearrangement of our methods of valuation as applied to gas supply. Already in the committee rooms of the Houses of Parliament scarcely a gas bill now goes through without questions of calorific value arising; and everything points to the probability that before long clauses as to calories as well as candles will add to the terrors of the gas manager's life.

At the present moment, the view taken by the average gas manager is that a standard of calorific value would be a relief after the chaos which law and science have succeeded in producing under the title of candle power. But should clauses as to heating value be accepted without due consideration and greatly extended knowledge, it is to be feared that in years to come gas undertakings may find them a serious hindrance to advancement, by binding them down to processes and qualities of coal which might with advantage be abandoned. My desire this morning is to discuss the problem of heating value in such a way as to show the conclusions we can arrive at from our present knowledge, and the lines on which investigation can most profitably be carried out. For many years to come it will be impossible to divorce the old form from the new; and candle power must remain side by side with calorific value. So that the first thing to be done is to bring them into agreement, and to realize clearly the relation that exists between them.

In some Cantor lectures given last autumn it was pointed out that, in considering the question of the illuminating value of the gas and its calorific value, it must be apparent to everyone who has studied the question that no definite relation can exist between them. One may take a dozen samples of illuminating gas of the same candle power, each of which will differ from the others in its composition; and as the calorific value is entirely dependent on the composition, it will often be found that two 16-candle gases vary in calorific value to a greater extent than between a 16 and a 15-candle power gas more nearly equal in composition, while these discrepancies are to an enormous extent increased by variations in the method of determining the illuminating value. By adopting, however, a rational process of testing the candle power, and taking the mean of an enormous number of calorific determinations, it is found that an average relation can be obtained which may be taken as the basis for considering this question.

Although scientific gas testing may be said to have been in vogue for 35 years, recent events seem to show that we still stand in sad need of common sense in the application of our knowledge; and when we are gravely informed that the right way of testing the candle power of a gas is to begin by destroying a large percentage of the light that the gas is capable of developing, and measuring the remainder with every detail of scientific accuracy, we feel that we understand what the old metaphor meant by "straining at a gnat and swallowing a camel." It was my intention to go fully into this portion of the question, and to bring before you the results of many long sets of tests showing the importance of recognizing the effect of the standard burner on the quality of the gas to be tested; but Mr. Grafton has dealt with this subject, and it cannot be left in more able hands. I must, however, give briefly my own conclusions on the subject so far as they bear upon the relation between candle power and calorific value.

I may at once say that if the historic method of testing the illuminating value of gas by burning it at the 5 cubic foot rate in a "London" Argand is to be maintained, no relation will be found between the two—save that with a slight fall in heating value a great and varying loss in illuminating value takes place. This is due to the fact that the true calorific value is being obtained for the lower qualities of gas; while their candle power is merely a record of the residuum of light obtainable after improper burning has destroyed a variable proportion of the light-yielding constituents. I say variable advisedly, as a gas which gives an illuminating value of 14 candles when tested by a rational method may give anything from 13 to 11.5 candles when burnt at the 5 cubic foot rate in the "London" Argand, according to whether it is a pure coal gas or a diluted gas.

The idea that a parliamentary definition made over 30 years ago must

hold good under the altered conditions of to-day seems to me utterly opposed to all common sense. Then we had the "London" Argand, the 5 cubic foot rate, candles, and the open bar or box photometer. As far as London is concerned, the candles are gone, the old photometer has passed away, and in their place the Referees have given us the far superior 10-candle lamp and table photometer devised by Mr. Harcourt. No parliamentary sanction seemed necessary for these changes; the Referees were all powerful. Moreover, the 5 cubic foot rate seemed to offer no insurmountable difficulties, as with the table photometer the gas has to be burnt to give a definite light; and the value of the 5 cubic feet is left to arithmetical methods. Yet when it is shown that the "London" Argand is only fitted—indeed, only constructed—to develop properly the light from a 16 to 17-candle gas when consumed at the rate of 5 cubic feet per hour, and that with a low illuminating gas an error (not of small fractions of a candle, but of whole candles) may be introduced, a cry of pious horror goes up at the thought of altering the standard.

The fact that the Board of Trade have promised to appoint a committee to consider the whole question, gives hope for the future. But at present all is chaos. For the purposes of the experiments made for this lecture, I have employed the method of testing illuminating power by burning the gas to a light of 16 candles in the "London" Argand and calculating the candle power for 5 cubic feet—a method which, although it does not give quite so high a candle power as can be obtained from specially constructed Argands, or from the "London" Argand as altered by Mr. Grafton, yet has the advantage of being applicable in every gas works where photometric apparatus exists, and which is very fairly accurate over a range of from 12 to 17-candle gas.

Before attacking the question of calorific value of coal gas, I think it will help us to consider the heat relations of its constituents, as we shall then more clearly realize the factors that govern the results we obtain. In all the many lectures I have given on the composition of coal gas, I have insisted on the importance of the methane present as yielding not only a part of the light, but in giving size and stability to the flame. When we come to consider the thermal side of the question, one is more than ever impressed with the fact that it is the presence of a considerable percentage of this gas that gives coal gas its pre-eminence as a factor in producing not only light, but heat.

The heat value of a gas may be arrived at either by calculation or by direct experiment. As an example of the first, we may take methane, which will give us a fair idea of the troubles that beset our path. The beautiful work of Andrews, Thomson, Favre and Silberman has given us the basis upon which all calorific calculations are founded. Burning a unit weight of pure carbon under conditions which insured the whole of the heat developed being transmitted to water, they found that 8,080 unit weights of water could be raised 1° C., and that under the same conditions a unit weight of hydrogen would raise 34,400 units of water 1° C.; hence they ascribed the value of 8,080 thermal units to carbon and 34,400 to hydrogen.

When a gas consists of carbon and hydrogen only, it is often considered sufficiently accurate in practical working to determine its percentage composition by weight, and then to multiply the carbon found by 8,080 and the hydrogen by 34,400—the sum of the two resultants, divided by 100, being taken as representing the calorific value of it as a fuel. On analysis, we find methane has a composition of 75 per cent. of carbon and 25 per cent. of hydrogen; and

$$\frac{(75 \times 8{,}080 + (25 \times 34{,}400)}{100} = 14{,}660.$$

14,660 would, therefore, be taken as the calculated calorific value of methane.

Now such a calculation introduces two serious errors: First, in the act of combining heat is either evolved or absorbed; and to break up a chemical substance, it is necessary to expend just as much heat as was evolved during its formation. For many gaseous substances, this is easily arrived at. But for solid and liquid fuels it is an unknown factor; and, consequently, for these all calculations are of very little value.

It has been shown over and over again that coals having the same percentage composition, and hence the same calculated calorific value, differ in heat value when examined by a calorimeter. Secondly, the value for carbon has been determined for solid carbon; and even this value varies from the different forms of carbon, and for the same form by different observers. It is evident, however, that the carbon does not exist in the solid form in methane. Consequently, such formulæ introduce errors of totally unknown magnitude, either with solid or liquid fuels, and are often not reliable for gases. Various speculations have been made as to the magnitude of these errors; but nothing of a satisfactory nature can be deduced from them.

How serious the first may be is shown in our previous calculation of the calorific value of methane, of which we know the heat of formation. Calculating, as before, the heating effect of methane, we find that it has a thermal value of 14,660 units. But the heat of formation of the molecule of methane (CH_4) is + 20,414 units; and our value for methane corrected would be—

$$14{,}660 - \frac{20{,}414}{16}$$

or 13.384 thermal units—a number much more nearly approaching that which is obtained as a result of actual experiment.

Taking, now, 13,384 as the pounds of water raised through 1° C. by the complete combustion of 1 pound of methane, we have to reduce this factor to B.T.U.—*i. e.*, to pounds of water raised 1° F. by the combustion of 1 cubic foot. In round numbers, 23.5 cubic feet of methane weigh 1 pound. So that $\frac{13{,}384}{23.5} = 596.9$ pounds raised 1° C.; and as a degree of the Centigrade scale is $\frac{9}{5}$ths of a degree F., $\frac{596.9 \times 9}{5} = 1{,}024.2$, which is therefore the gross calorific value in B.T.U. The combustion of the hydrogen in the methane, however, forms water, the conversion of which into vapor renders a certain amount of the heat developed latent; and a deduction for this reduces the figure to 919 B.T.U., which is the net value of this particular sample of gas.

A good example of the confusion created in the lay mind by scientific utterances is to be found in the calorific value of hydrogen. A pound of hydrogen when burnt evolves more heat than a pound of any other known substance; and as a rule this has given rise to the impression that this gas must be the most valuable of all gaseous fuels. The fact is, however, overlooked that it is also the lightest known element, and that it takes no less than 186.5 cubic feet to weigh a pound, so that the heat value of the cubic foot is only 325 B.T.U. gross; while the fact that water is the only product of its combustion, lowers the net value to 272 B.T.U.—a lower duty even than that of the product of the incomplete combustion of carbon (carbon monoxide, which yields 330 B.T.U., both net and gross; there being no water to vaporize, and no heat therefore rendered latent during its combustion).

Taking the main constituents of coal gas and tabulating them according to their calorific value taken in round numbers, we may state them as follows:

Description of Gas.	Calories per Cubic Foot. Gross.	Calories per Cubic Foot. Net.	B.T.U.'s per Cubic Foot. Gross.	B.T.U.'s per Cubic Foot. Net.
Benzene vapor.....	938.9	902.5	3,718	3,574
Ethylene.....	404.8	381.3	1,603	1,510
Methane.....	258.6	232.0	1,024	919
Carbon monoxide..	83.3	83.3	330	330
Hydrogen.....	82.0	68.7	325	272

Taking, now, an ordinary sample of 16-candle power coal gas as supplied to the city, and applying these values to its combustible constituents, we have:

Hydrogen.....	54 per cent.	× 325 =	17,550
Methane.....	34 "	× 1,024 =	34,816
Ethylene.....	3 "	× 1,603 =	4,809
Benzene.....	1 "	× 3,718 =	3,718
Carbon monoxide	6 "	× 330 =	1,980
			62,873

or 628.73 B.T.U. gross for a cubic foot; while if the calorific value be tested direct in the calorimeter, we obtain, as the value of the mean of ten determinations by the Junkers' calorimeter, 157 calories per cubic foot, or 157 × 3.968 = 623 B.T.U.

For every reason the experimental determination of the calorific value of a gas is the most satisfactory, the easiest, and most reliable method, as calculation necessitates an accurate analysis of the gas which is very difficult to obtain, and which would not only make the calculation of the calorific value a most laborious operation, but would also leave loopholes for so many sources of error that the results would be open to grave doubt. Given a good analysis, however, calculation enables one not only to obtain the calorific value under conditions where direct determination would be impossible, but also affords us an insight into the cause of any abnormal variation in thermal value which might otherwise be difficult to trace. Taking the calculation of the calorific value just given, it is clear that more than two-thirds of its heating power is due to the hydrocarbons present in it, and that methane is the factor which makes a good coal gas so superior to all other forms of gaseous fuel.

The possibility of directly determining the calorific value of a combustible gas has only been placed within the reach of the gas manager during the past 10 years by the introduction of that beautiful instrument that we all know as the Junkers' calorimeter, and which has been so often brought before you as to need no fresh description from me. In this instrument, the heat generated by a flame is transmitted to water; measurement of the gas burned, and the volume and rise of temperature in the water giving all the data necessary to calculate the calorific value of the gas. The ease, rapidity and accuracy with which determinations of thermal value in gases could be made by this apparatus have in reality created the possibility of a practical standard of heat value; and, as was to be expected, a rival calorimeter has appeared on the market in a modification of the Junkers apparatus known as the Simmance-Abady calorimeter.

I have frequently been asked as to the relative accuracy of the two forms of apparatus; and in order to provide an answer to the query, I have had long series of tests made by independent observers working alternately with the two instruments on the same gas, and find that the differences in results obtained from the two forms of apparatus are not greater than the differences obtained between tests on the same apparatus. So that, in practical working, there is nothing to choose between them. I may, however, warn intending users as to the importance of seeing that the thermometers supplied are carefully checked for uniformity over the range of temperature at which they are likely to be used, as a very small discrepancy in the calibration will introduce a serious error into the results.

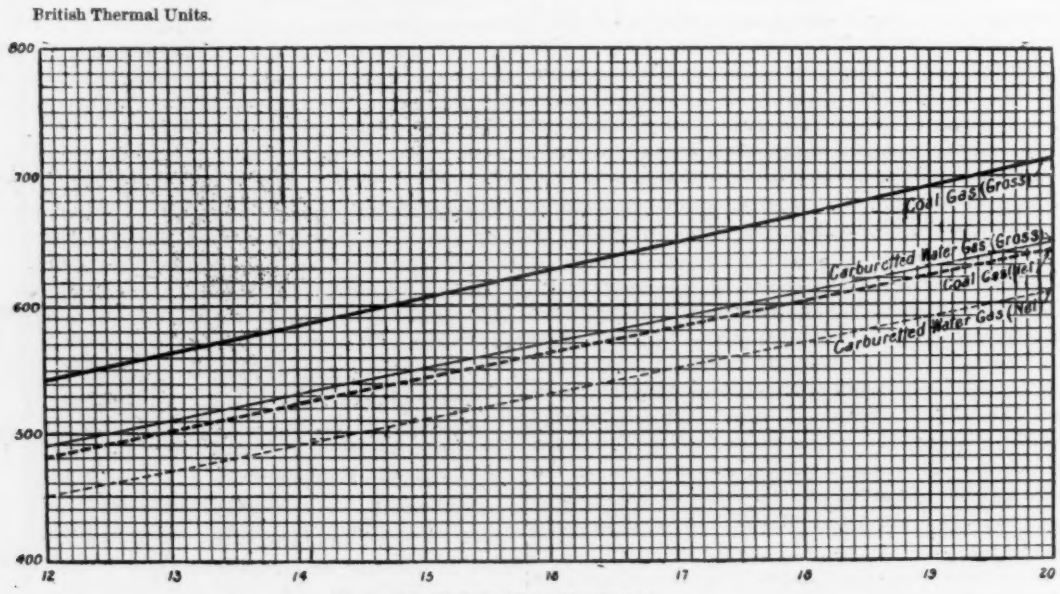
A point also on which considerable confusion seems to exist in the lay mind is the relation between the calorie and the British thermal unit. For all scientific work the metric system of weights and measures is employed; and the calorie represents the amount of heat required to raise 1 liter (1,000 grammes, or 1 kilogramme) of water 1° C. So that when the statement is made that a gas has a calorific value of 157 calories per cubic foot, it means that, on complete combustion, it yields enough heat to raise 157 liters or kilogrammes of water through 1° C.

The unit of heat used in English commercial work is, however, the British thermal unit, which is the quantity of heat required to raise 1 pound of distilled water through 1° F.; and a factor can easily be found for converting the one unit into the other. The kilogramme is equal to 2.2 pounds; while the degree on the Fahrenheit scale is equal to $\frac{9}{5}$ths of a degree Centigrade. So that 1 calorie equals $\frac{2.2 \times 9}{5} = 3.96$ B.T.U. Therefore, calories multiplied by 3.96 become British thermal units; while the latter, divided by 3.96, give calories per cubic foot. For ordinary conversion work, however, it is often considered sufficiently accurate to multiply the calorie by 4 to obtain the British value.

Having now cleared the ground, we can return to the question of the relation existing between the illuminating and calorific value, and the points to be considered in the future in defining a calorific limit to a coal gas supply. If the same coal be used for all tests, and varying illuminating powers be obtained by varying the temperature at which the coal is carbonized, fairly concordant results will be obtained—that is, the loss in calorific value will fairly well follow the loss in illuminating value. But directly another kind of coal is employed, a wide divergence from the previous results is found, and analysis at once shows that this is due to variations in the proportions of hydrocarbons present. In the same way, if carburetted water gas made with the same grade of oil is tested. and the illuminating power varied by altering the amount of oil cracked, perfectly regular results are obtained down to a certain limit, below which the illuminating value decreases far more rapidly than the calorific value. But change the oil, and use American instead of Russian, or *vice versâ*, and at once a different ratio is obtained.

It is clear from this that it is not possible to take a calorific value as indicative of any particular illuminating value, or say that such a candle power gas will have a definite calorific value, because a 16-candle gas may be anything between 575 and 650 B.T.U. gross, and will vary between such limits according to the kind of coal used for its production, or whether it is a pure coal gas or a mixture with carburetted water gas. In fact, every alteration in composition is reflected in the calorific value. As, however, calorific tests made on varying grades of coal gas are collected in greater and greater numbers, and are entered in diagrammatic form, the more nearly does a line drawn through the center of the myriad points approximate to a straight line, until now, after several years' testing, the calorific value of various grades of coal gas from every part of the country, and made from all sorts and classes of coal, and treating them as described, I have obtained the average relation shown for coal gas, and also the second curve for carburetted water gas.

Taking the original diagram, the lines appear to run through a haze of spots, somewhat resembling a chart of the Milky Way, and which are only rendered straight by their equidistance from outlying points; while those points distant from the main average lines themselves again fall into secondary lines in the same direction, but on different planes to the main lines, and which represent the curves of calorific value for coals of the same kind. I want it clearly understood that this diagram is merely put forward as the average relation between the illuminating power of a pure coal gas and its calorific power, and that the variations from the line may amount to 5 per cent. or even more. But with this reservation, it gives a definite idea of the relation existing between candle power and calorific value.



Candle Power by 16-Candle Rate.

Taking, now, the chart, our average calorific value may be tabulated for each candle power between 12 and 20 as follows:

Calorific Value of Pure Coal Gas.

Candle Power.	Calories. Gross.	Calories. Net.	British Thermal Units. Gross.	British Thermal Units. Net.
12	136.0	120.6	510	480
13	141.0	125.6	560	500
14	147.0	131.2	585	522
15	153.2	136.2	610	542
16	157.0	141.2	625	562
17	162.5	146.2	647	582
18	168.3	151.2	670	603
19	173.3	156.3	690	622
20	178.8	161.3	712	642

Calorific Value of Carburetted Water Gas.

Candle Power.	Calories. Gross.	Calories. Net.	British Thermal Units. Gross.	British Thermal Units. Net.
12	123.1	113.5	490	452
13	128.1	118.6	510	472
14	132.9	122.8	529	489
15	137.4	127.6	547	508
16	142.4	132.4	567	527
17	147.5	137.4	587	547
18	152.7	142.4	607	567
19	157.5	147.5	627	587
20	162.5	152.5	647	607

This gives us a basis upon which it is possible to go in the event of it being desirable to define calorific value, as well as candle power, in a Gas Act. If, for instance, a gas company desire to supply a 12-candle gas, and the authorities on their side want the calorific value prescribed as well as the candle power, a margin of at least 5 per cent. from the average recorded calorific value should be taken. That is to say, the gas should be prescribed of 12-candle power and not less than 500 B.T.U. gross heating value; while if the manager desired to largely utilize dilution with water gas, then the standard calorific value would have to be lowered, and the gas prescribed as of 12-candle power and not less than 460 B.T.U. gross heating value—such definition leaving a margin of 5 per cent., which appears necessary in our present state of knowledge.

I should like to point out here that a most important piece of research work remains to be done with regard to the calorific value of coal gas, and that is the tabulation of the calorific value of the gas obtained from various grades of coal. Should any works that are blessed with a complete experimental equipment find it possible to do this, the data will be of the utmost value in the near future when this question must be dealt with.

In many of the published results regarding the relation between calorific power and illuminating power, the experiments have been rendered useless by the low illuminating power having been obtained by "stripping" the gas—*i. e.*, by taking out the unsaturated hydrocarbons to a greater or less extent by bubbling the gas through petroleum. It is possible, working in this way, to obtain a gas which will remain almost constant in calorific value, while the illuminating power descends with great rapidity. This result is due to the fact that the methane, which gives considerably more than half the heating value, remains untouched, while the benzene and ethylene, which were the main factors in the illuminating value, alone are withdrawn; and these representing only a very small percentage of the heat-giving constituents of the gas, the loss is naturally a very slight one as regards the calorific value.

This point also shows the effect which various methods of enrichment have upon calorific value. If the candle power of a pure coal gas rises, it is because a larger percentage of illuminants from the coal are present, and at the same time that one gets an increase in the unsaturated hydrocarbons, and a consequent increase in light, a *pro rata* increase is also obtained in the saturated hydrocarbons—such as methane—and consequently a relative increase in the heating value. But if a poor coal gas be enriched by adding to it (say) benzol vapor, the enrichment in candle power takes place without so great an enrichment in heating value. This is at once seen when one considers the relation between the light yielding and the calorific values of such hydrocarbons as are present in the coal gas.

Description of Gas.	B.T.U's Gross.	B.T.U's Net.	Illuminating Value per 5 Cubic Feet.	B.T.U. per Candle.
Methane.....	1,024	919	5.2	984.6
Ethylene.....	1,603	1,510	70.0	114.6
Benzene vapor....	3,718	3,574	820.0	22.6

It is clear from this that if a coal gas is taken in which a large proportion of the illuminating power is due to the presence of methane and ethylene, for any given illuminating power it must have a higher calorific value than when the illuminating power is due to the addition of benzene vapor.

It is impossible to leave the question of candle power and calorific value without some reference to the value of the thermal power to the consumer. It was the incandescent mantle that led to reduction in illuminating power in the gas; and the relation between the calorific value of a gas and the light to be obtained from it by the mantle is therefore a question of the utmost importance. In the Cantor lectures given last autumn, I pointed out the fallacy of supposing that a regular fall in the light to be obtained from a mantle takes place with the fall in the calorific value of the gas; and as this seems to have created some dissatisfaction in the minds of those who supported the idea that high candle power and high calorific value means increased efficiency in the mantle, I should like to say a few more words in explanation.

The light emitted by an incandescent mantle is partly due to the catalytic action taking place upon its surface, and also largely due to the temperature of the flame which is heating the mantle. The popular idea seems to be that the temperature of the flame is governed by the calorific value of the gas. This, however, is an utter fallacy. The calorific value of a gas represents the total amount of heat which the complete combustion of the gas can yield; but the temperature of the flame produced by the combustion will depend: (1) Upon the time in which this volume of gas is consumed; (2) on the area in which the combustion takes place; and (3) upon the amount of air needed for completing the combustion and the specific heats of the products of combustion of the flame and the residual nitrogen from the air, which in their escape remove heat from the flame. It is clear that if a cubic foot of gas contains (say) 500 B.T.U., while another contains only half that quantity, if twice the volume of the second can be burnt in the same time and space, the two flames will probably be about the same temperature. In arguing upon the effect of the calorific value upon the light emitted by the mantle, it seems to have been generally overlooked that it is the intensity of the flame which will be the important factor and not the calorific quality of the gas employed.

I pointed out in my Cantor lectures that I had obtained over 19 candles per cubic foot with water gas; and I thought that as burners had been advertised as giving 20 candles a foot with this combustible, it was a well recognized fact that a high candle power could be obtained. But to my surprise, I received many communications to the effect that no such duty was attainable. This caused me to go again into the matter. I procured a number of Strache and other water gas burners from abroad; and, through the courtesy of Mr. Goulden, a holder of water gas was placed at my disposal at Beckton. From none of these burners, however, could I obtain a higher result than about 15 candles per cubic foot. But in looking through my old burners, I found the one with which the original tests had been made. This was a fuel gas burner hailing from Philadelphia, and which, as far as looks went, was practically identical with those of Continental make, but with a little better finish and cleaner holes. With this burner, as the mean of tests with a "C" Welsbach mantle in four positions, 19.38 candles per cubic foot of gas consumed were obtained; the mean of four readings being 158 candles for a consumption of 8.15 cubic feet of water gas at a pressure of 1.3 inches. The chimney employed was 5 inches by 2 inches, which gave better results than a longer one; it being evident that under these conditions one got just the right air supply.

The water gas was purified from carbon dioxide, and had a calorific value of 81.86 calories gross, and 74.66 net. In this case, one has a gas of 81.86 calories, or 325.7 B.T.U., giving the same light per cubic foot of gas consumed as under the ordinary conditions with a "C" Welsbach burner it would give with a good coal gas having a thermal value of 630 B.T.U. It is clear, therefore, that calorific value for this purpose is not so important a factor as some people would have us suppose.

Coming to the question of flame temperature, one finds that the coal gas gives a flame the temperature of which will be somewhere about 1,660° C.; while the temperature of the water gas flame, according to the determinations made by Herr Blass, approximates to 1,775° C. The explanation of the higher temperature of this flame is that, in the first place, a much larger volume of water gas than coal gas could be burnt in the same space, and that the gas, being non-luminous, the air supply can be entirely obtained from exterior sources, and is less in volume than with coal gas. Under these conditions, the residual nitrogen of the air and the products of combustion, in their escape from the flame, are probably not heated to so high a temperature as when the larger proportion of air necessary with coal gas is passed into the Bunsen burner with the gas, and therefore passes through the whole body of the flame.

The ordinary "C" burner and mantle would require just about 4 cubic feet of a gas having a calorific value of 630 B.T.U. in order to yield the best results; while in this experiment just double the quantity of gas was consumed. The light also is nearly double; this being due to the well known fact that the conversion of heat into light becomes enormously greater the higher the temperature. A still more striking illustration of the fact that high calorific values are not necessary for the incandescent mantle is that it is found possible to use gases of even lower calorific value than water gas. It has been universally considered impossible to utilize such fuel gases as those produced by the Wilson, Mond, Dowson and other processes of the same character for illumination by means of the incandescent mantle, owiug to the low ther-

mal value of the gas and the comparatively low temperature of the flame.

It is evident that from one-half to two-thirds of the volume of fuel gases being composed of inert nitrogen and carbon dioxide, the combustible constituents are not only diluted, but the diluents also retard combustion by keeping away the air to a certain extent from the burning gas; and the flame produced is large and of low intensity. With such gases, the idea that further dilution with air could in any way increase the intensity of combustion in the flame to a degree that would render it practically useful for mantle lighting and heating by small flames never seems to have been entertained until Messrs. Tatham and Chamberlain discovered that, by taking an atmospheric burner of special construction with a carefully regulated air supply, the combustion could be so intensified that gases of low caloric value could be utilized for purposes that up to that had been considered as being only attainable by the use of coal gas.

In testing this process, the gas was made by the injection of air and steam into a producer, in which the fuel used was anthracite nuts. Two samples of the gas taken during the lighting and heating tests gave me on analysis the following results:

		I.	II
Combustibles	Carbon monoxide	29.22 per cent.	28.76 per cent.
	Hydrogen	25.95 "	26.37 "
	Methane	1.39 "	1.97 "
Noncombustible	Nitrogen	39.33 "	38.92 "
	Carbon dioxide	4.11 "	3.98 "
	Oxygen	nil "	nil "
		100.00	100.00

These analyses show the gas to be of exceptionally good quality. This is borne out by the calorific value; the mean of a long series of determinations made by the Junkers calorimeter giving the calorific value as 198.5 B.T.U. gross and 184.3 B.T.U. net.

This gas was burnt in the Tatham burner fitted with an ordinary Welsbach "C" mantle; and in the first burner tried gave the following results:

Gas Pressure. Inches.	Gas Consumed per Hour. Cubic Feet.	Light. Candles.	Candles per Cubic Foot.
2.0	22.5	80.0	3.35

With a second burner, with outside mantle support instead of rod, these results were very much increased, and I obtained:

Gas Pressure. Inches.	Gas Consumed per Hour. Cubic Feet.	Light. Candles.	Candles per Cubic Foot.
2.0	30.0	150.0	5.0

One of the factors which has led to the many discrepancies in the light ascribed to incandescent mantles is to be found in the difficulty of comparing upon the disk the greenish white light from the mantle with the yellowish orange light from the standard; and a distinct advance has been made in mantle photometry by the introduction by Messrs. Simmance and Abady of a form of photometer which eliminates this trouble.

In the ordinary process of photometry, the two lights fall upon opposite sides of the disc. One side shows a distinct greenish tint, while the other shows an equally distinct orange; and it is only with very long practice that the eye gets sufficiently trained to obtain an equalization of light, with the result that there are only a very few photometrists in the country whose results on a mantle I should have confidence in. It has been found, however, that if the disk be illuminated on one side only by the two lights, both falling on the same spot, and they are alternately screened by a rapidly moving shield, the eye fails to distinguish the two colors, and takes note of the illumination only. So that while the lights are unequal, a flickering sensation is produced upon the retina; but as soon as equality of illumination from the two lights is secured, the flickering ceases, and the spot on the disk becomes steadily illuminated with a greyish light built up of the two colors.

In the new photometer, this principle is applied to what is primarily a Harcourt table photometer, in which the pentane lamp is displaced by the burner taking the incandescent mantle; while in the place of the "London" Argand, is an Argand the gas supply of which is governed by a micrometer clock. The light from the incandescent mantle and from the argand both fall on the photoped in the ordinary way, and behind this is fitted a rapidly moving shutter, which alternately cuts off the light from the two sources and which is driven by a small electric attachment. In making a test, the observer starts the electric motor and regulates the gas supply of the argand burner until the cessation of flickering on the disk indicates that the light from the standard is equal to that from the mantle; and he then determines the actual power of the Argand which has been used as the standard by directly comparing it with a 1-candle pentane lamp fitted to a photometer bar in line with the Argand, which is so arranged that the two operations can be conducted without the observer leaving his seat.

It seemed to me that this new departure is so important, having regard to the progress made by the incandescent mantle, that I instituted a series of tests with it in order to see how results obtained by a practised mantle photometrist on the open bar would agree with the results obtained by another observer on the new photometer. In order to carry out these tests, Messrs. Alexander Wright & Co. fitted one of the photometers for me in a darkened room at Greenwich; and an open bar photometer with a 10-candle standard was placed in line with the incandescent mantle on the table photometer, so that direct results on the bar could be made at the same time as the readings on the "Flicker" photometer.

In making these tests, I did not confine myself to the ordinary Welsbach mantle, but used several kinds of mantle giving different tints of light—such as the old red chrome alumina "Sunlight" mantle, with its rich orange light, Continental fuel gas mantles, with that indescribable greenish glare which characterized the early Welsbach mantles, and with ramie, collodion, and cotton mantles of English and foreign manufacture—and obtained the results given in the following table:

Comparison of Various Mantles—Simultaneous Tests by the Simmance-Abady, "Flicker" Photometer and the Bar Paotometer.

Mantle. Observer.	Photometer. Bar. I.	Photometer. "Flicker." II.	Photometer. Bar. II.	Photometer. "Flicker." I.
Pink Sunlight	32.0	36.0	31.0	30.8
	31.0	30.0	28.5	34.4
	33.0	34.4	28.5	32.8
	32.0	30.0	28.0	31.6
	32.0	32.6	29.0	32.4
Collodion	86.0	84.0	81.0	78.0
	86.0	80.0	83.0	78.0
	85.0	82.0	85.0	80.0
	86.0	82.0	86.0	78.0
	85.75	82.0	83.75	78.5
Ramie "Crown"	70.0	65.0	69.0	62.0
	70.0	65.0	72.0	64.0
	70.0	66.0	71.0	64.0
	70.0	68.0	70.0	62.0
	70.0	66.0	70.5	63.0
German Water Gas Mantle	65.0	62.0	65.0	61.0
	66.0	64.0	66.0	61.0
	65.0	62.0	66.0	61.0
	65 0	61.0	66.0	61.0
	65.25	62.25	65.75	61.0
Ordinary "C" Welsbach	66.0	67.0	67.0	66.0
	66.0	67.0	68.0	64.0
	68.0	69.0	67.0	64.0
	67.0	67.0	68.0	64.0
	66.75	67.5	67.5	64.5

It is clear from these tests that this form of the "Flicker" photometer is not only a very distinct advance on the means at our disposal for determining the light of incandescent mantles by doing away with the personal error, which must always be a very great one with two lights of unequal color, but also that the results given by it are practically identical with those obtained on the bar photometer; the discrepancies apparent in some of the tests being due to the vagaries of the 1-candle pentane unit, which is utilized for standardizing the Argand. Messrs. Simmance and Abady tell me they have now successfully applied the principle to the open bar photometer, so that the 1-candle unit can be replaced by the ordinary 10-candle lamp, which will remove the only objection that I can see to the general introduction of this form of photometer.

In conclusion, I can only hope that this lecture may not have been wearying owing to the necessarily dry details regarding calorific value, and that it may be found of practical utility in the future when the question of calorific value comes to be fought out in the Committee rooms of the Houses of Parliament.

The President said the members had, no doubt, all come expecting a brilliant lecture; and their expectation had been more than realized. The subject was one of very great importance at the present time; and Professor Lewes had given them a great deal of information which

would be most useful. He had also, by the wonderful power he possessed, roused their attention; and he was sure they would apply to great advantage the information they had received.

Mr. W. King (Liverpool) said it was with very great pleasure that he rose to propose that the best thanks of the meeting be given to Professor Lewes for the important, instructive, and most brilliant lecture with which he had favored them. Without disparagement to other gentlemen of ability who had from time to time addressed the old Associations, he could safely say there was no one to whom they listened with so much pleasure and edification as to Professor Lewes. They must all envy him his marvellous powers of memory, and the wonderful art of concealing art. He interested them in what he called dry details, which, however, did not appear dry from his lips; and they must envy him that power, and rejoice to be able to listen to a gentleman who could treat these matters in so instructive, brilliant, and entertaining a manner.

Mr. W. A. Valon (London), in seconding the motion, said he need add nothing to the remarks of Mr. King. The name of Professor Lewes was a household word among the gas profession. Whenever they heard that a lecture was to be delivered by him, their state of mind was in the first instance one of expectation; and they were never disappointed in the result. He had the power of gathering round what would otherwise be dry details a beauty of description which amounted almost to fascination; and they also found at the close the great satisfaction that they had learned from him something they had not known before.

The motion having been carried by acclamation,

Professor Lewes, in reply, said although a good deal of the matter he had brought before the meeting was excessively elementary, still he thought much of it was of great importance to the gas world in the future. There was one point especially he should like to bring out. There was a vast field at the present moment for a most important piece of research work. Any gentlemen who had the good fortune to have extremely efficient plants in their works, would be conferring a very great benefit on the gas industry if they would take the various grades of coal—coals from the various fields—and determine the relationship existing between the thermal value of those coals. There had been plenty of work done on the different values of coals in respect of their gas-yielding properties, and factors of that character, but none on the calorific value of the gas obtained from distinct and separate classes of coal. There was such a wide difference between gas produced from North Staffordshire and Durham coal, that he imagined they would find a good deal of food for thought if such experiments could be carried out; and they would be of enormous value in the near future. As soon as they got into the meshes of the calorific standard, as well as the illuminating value, it would become one of the prime factors in calculation. Some coals gave good illuminating value and very poor calorific value; and they wanted to know which were the coals they could rely upon for one as well as for the other.

Some Recent Effects of Electrolytic Action Upon Underground Mains and Other Metals.

[A paper read by Mr. A. A. Knudson, New York city, at the Detroit meeting of the American Water Works Association.]

The destructive effect upon underground mains and other metals, caused by railway currents through the well-known process of electrolytic action, has now become so well understood that a collection of data only in the shape of ruined pipes would be of but little value as a paper. We propose, therefore, to briefly refer to a few items concerning the movements and effects of the ever busy railway current, in its wanderings up-and-down and to-and-fro through the earth, seeking such pipes and metals as it may devour.

When it is considered that all movements of electricity are governed by well established laws, it may be well to first turn our attention for a few moments to the law governing returning railway currents under the prevailing single trolley system. This law of derived or divided circuits is concisely stated by one authority as follows:

"When several paths are open to the current, it divides itself among them all in the inverse ratio of their several resistances." The networks of iron pipes under the streets of a city constitute another path, besides the rails, through which a proportion of these currents, in conformance with this law, must pass in their return to the power house.

It has been found, when making 24-hour readings for current flow through mains, as well as 24-hour potential tests between mains and rails, that the variations correspond very closely to the habits of the traveling public, which, it is well known, are practically the same in every city. For instance, mornings and evenings a larger number of people use the cars than at other times in the day, and consequently a larger amount of current is required to carry them, and at such times we find a larger amount of current passing by way of the mains. As the traffic upon the cars becomes lighter, a less amount of current goes by way of the mains. Our first item, therefore, will be an attempt to illustrate this feature, and also the law referred to.

For the purpose of easy comparison, as well as a matter of interest, we have placed upon the diagram (Fig. 1), two load lines; the upper

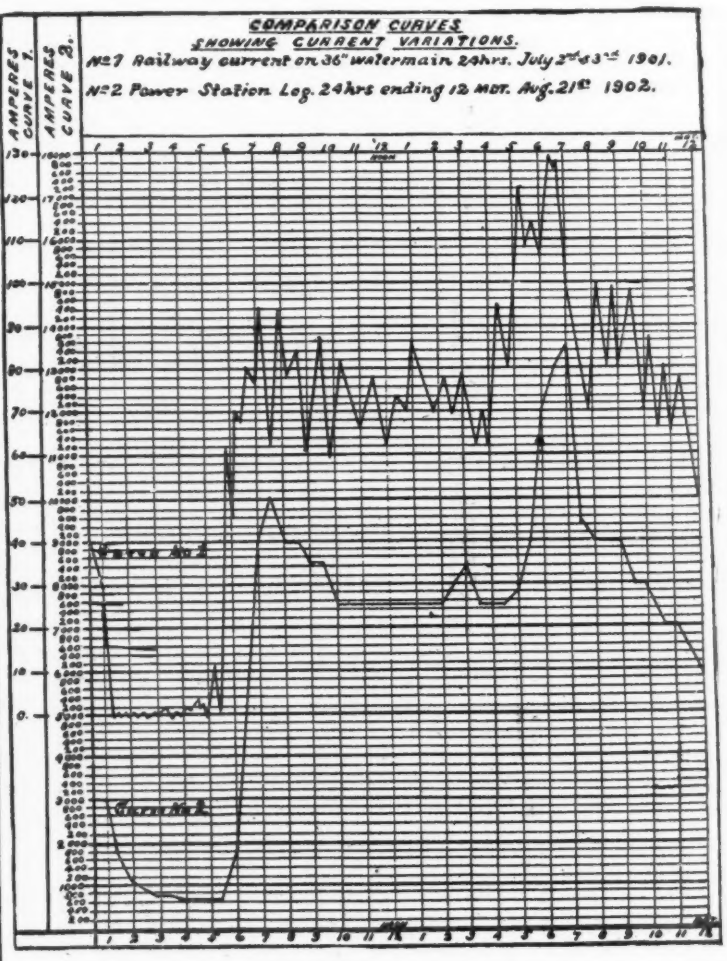

COMPARISON CURVES
SHOWING CURRENT VARIATIONS.
No 1 Railway current on 36" watermain 24hrs. July 2nd & 3rd 1901.
No 2 Power Station Log. 24hrs ending 12 MDT. Aug. 21st 1902.
AMPERES CURVE 1.
AMPERES CURVE 2.
Curve No 1
Curve No 2

Fig 1.

line, No. 1, represents a "load" of railway current flowing through a 36-inch water main in an Eastern city.

The lower line, No. 2, represents the output of a power station in the city of Detroit, and was taken from a 24-hour log, beginning at 1 A. M. and ending at 12 midnight, August 21, 1902. The readings in both cases, as will be noted, are placed at the same hours, so that the similarity in the rise and fall of current strength on the water main, and at the power house, at the same times of the day and night, are plainly shown.

This illustration is intended mainly to give a clear idea of the perfect unison of variation of current upon the mains with the variation of traffic upon the cars. As the curves show, beginning at about 5:30 A.M., the power house load increases rapidly up to 7:30, and in a similar manner so does the load upon the mains. This is caused by people using the cars so largely to carry them to their respective occupations. Towards the middle of the day the load is much lighter, until evening comes, when everybody wants to get home about the same time, between 5 and 7, when there is the second increase in current strength reflected in both curves. In the wee small hours of the morning, when but little current is required for an all-night service, little or no trolley current passes by way of the mains.

Fig. 2 refers to the same general principle, and shows the potential readings at a "rush hour" test taken between the hours of 5 and 7 in the evening, between the supporting pillars of the New York and Brooklyn Bridge terminal at the Manhattan entrance and a water main. The bridge structure was positive to the mains. The same rise and fall in these readings, as shown by the curve, will be noted corresponding to the traffic upon the cars.

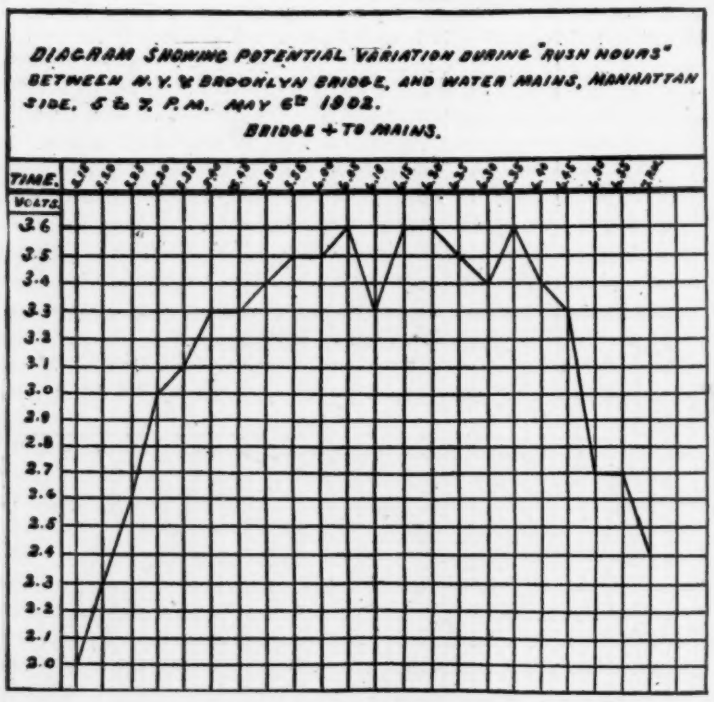


Fig. 2.

The object of occasionally making these tests is to ascertain the highest and lowest readings during 24 hours, or a given number of hours, as in this latter case, and also to establish when deemed necessary the identity and source of such currents.

The Passing of Current between Underground Mains.—This feature may prevail to a larger extent than generally supposed. It is a dangerous condition, because difficult to locate the different places where such action is going on. For instance, where two water mains may be parallel in a street a short distance apart, current flowing through one may cross to the other, and back again at several different places through the soil with consequent corrosion at the points of exit, or it may pass between a water main and a gas main. Such a case was discovered recently where two large mains, submerged in the salt water of a river bed, were found undergoing electrolytic action; the one found positive to the other, upon examination when uncovered at one of the banks, showed plainly this effect, and also the same action at the joints which could be examined of the main where current was flowing through it.

Another case illustrating this same feature, and somewhat difficult to solve (before it was discovered there were other pipes in the street), was found in a town in New Jersey, upon the lines of the Hackensack Water Company, and is referred to in Fig. 3. *A* represents an 8-inch water

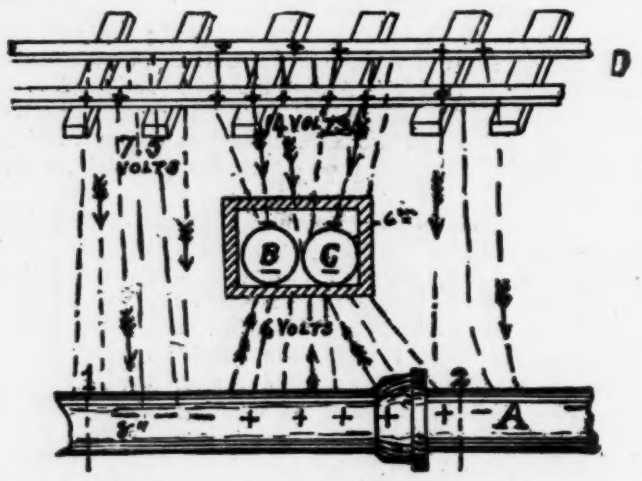


Fig. 3.—Electrical Conditions Causing Destruction by Electrolysis to 8-Inch Water Main.

main, *B* and *C* are two 6-inch wrought iron pipes belonging to the Standard Oil Company, and used for conveying oil to the seaboard. They are inclosed at this point in a wooden box. *D* are trolley rails upon the street. The water main, when uncovered, was found, between the points 1 and 2, to be practically destroyed by electrolysis. At one spot upon a hub we shaved the soft graphite down to a level with the main itself; at other spots upon the body of the main very nearly through. The point of importance in this case is, there were no indications whatever through any tests we could make upon the surface of the street that this main was being damaged by electrolysis. As you will note by the sketch the main was negative to the rails. After the oil pipes were discovered, however, the main was found to be positive to them from 5 to 6 volts. This, therefore, explains the cause of the destruction of this main by electrolysis at this point, helped, of course, by the fact that all three of these pipes were in a culvert where water was continually present. At last accounts the main was still holding out, but is being carefully watched, as it is liable to fail any time.

We could mention quite a number of similar cases found in personal examinations where electrolysis has left its indellible "trademark" upon iron pipes through the passing of current from one pipe to another through the soil. In further considering this same feature of the straying current, we will refer to electricity leaving a main and passing into the soil for a waterway, or other better conducting path, and mention, as an illustration, a recent case which we took considerable pains to trace. A 12-inch water main was examined which was located upon a river road, running north and south, on the west bank of the Hudson, for a distance of about 4 miles. Near the north end is located the power station supplying current to the railway a long distance in the country. Where the south part of the pipes takes this road, a trolley current of 12.7 amperes was found flowing north. A quarter of a mile further north another current reading showed but 3.5 amperes. Further examination resulted in finding evidence where the lost 9 amperes was forsaking this main for a cast iron sewer, thence through the sewer to the river. The main at this point when uncovered was found considerably damaged by electrolysis, the soft spots being large, and about half way through the iron. At the power house a 24-inch main—used to obtain water for condensing purposes—extends out into the river for about 100 feet. When the tide was low we obtained a current reading upon this main, and very nearly the same amount of current was found flowing through it from the river towards the power station that was forsaking the 12-inch main *four miles south*.

These two paths by which this current is returning to the power station—the water main and the river—give another illustration of the law of divided circuits. It also gives us the opportunity of comparing the relative conductivity of the two paths, viz., a 12-inch water main 4 miles long with about 1,800 joints, and the river; the river proving to be in this case about 75 per cent. the better conductor.

Similar instances have often been found of railway currents forsaking mains and taking water ways, particularly if salt water, where the power station is located on the banks of the same water way. This feature will again be referred to in our next illustration.

Peculiar Direction of Railway Current Through Mains, Bridges and Rivers.—This illustration is taken from a section of the city of New York.

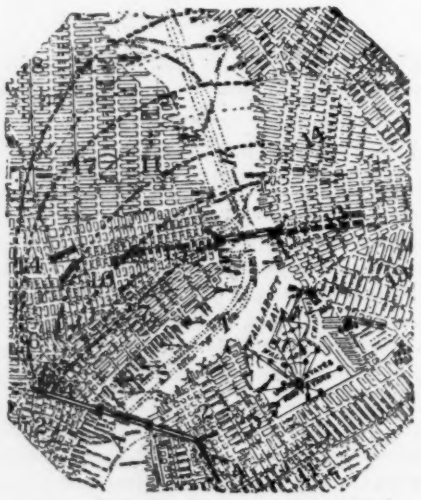


Fig. 4.—Map showing results of electrical measurements in boroughs of Manhattan and Brooklyn, New York city, March, 1897; October, 1898; May, 1902; March, 1903. Arrows indicate direction of returning railway currents. Figures, maximum voltmeter readings.

Since 1897 we have made at different times a number of tests in New York, and a few results are briefly given.

Fig. 4 will give an idea of the peculiar direction and movements of railway currents in one part of the city only.

In the spring of 1897 the writer discovered, while making an electrical survey in Manhattan, that a portion of the returning railway currents generated at the Kent avenue power station, Brooklyn Rapid Transit

Company, Brooklyn, E. D., passed over the New York and Brooklyn bridge to underground pipes in Manhattan. At that time it was supposed that these currents took the shortest and most direct path through these pipes back to Brooklyn, taking the river in the vicinity of Grand street, about opposite the power house, which is located on the water front in Brooklyn, at Kent and Division avenues.

In October, 1898, while making further measurements on the bridge, practically the same electrical conditions were found, viz.: Currents from Brooklyn flowing over the bridge and down the pillars in Park Row, which support the terminal structure and the elevated railway station, and from them to water and gas pipes in the street.

Last year, in the interests of parties engaged in a lawsuit, a more extended survey was made in this section of the city, for the purpose of ascertaining if there were currents of electricity flowing through underground pipes, what direction they were taking, and their identity and source.

It was discovered, as will be seen by the direction of the arrows and curve lines upon the map, that a portion of the Brooklyn railway currents generated at the Kent avenue power station, *in their return* to that station, pass over the New York and Brooklyn bridge to Manhattan, thence flow through underground pipes as far north as 23d street, and east towards and through the river to the Brooklyn side; thence through underground metals back to the power house. Tests made this year show that nearly all of this current, which formerly strayed so far north in the city, is cut off and now returns by a better path, namely, *the new East River bridge*. In order to ascertain these current movements, a large number of tests of various kinds were made, one of which will be mentioned. On the Brooklyn side, where this wandering railway current is *leaving* this structure, a reading was obtained upon a 6-inch, wrought iron pipe which is now led up to, and rests upon, the steel girders of the roadway, making a fairly good connection between the bridge structure and the water piping of the borough of Brooklyn.

This pipe supplies the engines upon the roadway with water. A current measurement (using the "fall of potential method") was taken upon that portion of this pipe which is close to the ground, and a maximum flow of 69.5 amperes was found passing off the bridge through this medium to the Brooklyn mains.

Further tests, between the pillars supporting the approach and the water mains in Brooklyn, show differences of potential ranging from 2 to 3 volts, the structure positive to mains—indicating *other* paths in the shape of a large number of pillar foundations, from which portions of this returning current may flow and cause corrosion through electrolytic action. In this same section of the city is located the U. S. Navy Yard. It has been known for some years that pipes in the Navy Yard have been destroyed from time to time by electrolysis, evidence of which we have seen in a number of samples during recent visits.

A convenient method for taking potential measurements, arranged by the officers of the Navy Yard, is shown upon the map and in larger scale in Fig. 5. Wires have been run from a central station connecting

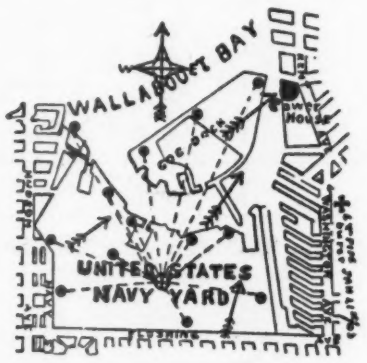


Fig. 5.—Navy Yard, showing points where test wires are connected with mains, and location of power house. Arrows show direction of railway currents through mains.

with the water mains at different points. By this method the difference of potential can be taken between any two points in the system—there are 14 of these connections. The directions of the railway currents upon the pipes are always towards the power station, which is located just across the channel from the Cob Dock. The most of the pipes which have been destroyed were in the Cob Dock. At one time it was feared that the steamship "Columbia," used as a receiving ship, was being damaged on account of being in line of these currents, but we are reliably informed that the plates of this ship were carefully examined when the boat was recently in dry dock, and no action, except that which might be expected from the water corrosion, was discovered. The difference in potential now between points on the sides of the yard near Flushing avenue and Navy street, to the point nearest the power station, is 20 to 25 volts; formerly it was higher than that.

The railway company at one time suggested that the damage caused and being caused to the pipes underground was not due to their currents, but was caused by the Navy Yard's own large electric light and power plant.

While the officials were morally sure that the currents causing damage were from the railway power station, the question remained unsettled until the day of the late President McKinley's funeral, when the Kent avenue power station, as well as all others in the country, closed down for five minutes.

It occurred to some of the engineers of the yard that it would be a good plan to make a few tests at that time, and while the Navy Yard's plant was running, and the railway power station closed down, this was done. It was found that the voltmeter needles *remained at zero* at every test made; proving conclusively that the currents causing the damage emanated from the railway power station.

These, in brief, are only a few instances of trolley current movements in the city of New York.

Several water and gas mains have burst in Brooklyn owing to electrolysis. We will, however, refer only to those of which a record has been kept in the section of the city we have been considering. Two views are shown, the only ones photographed so far as known. Fig. 6 represents an 8-inch water main which burst July 14th, 1899. The pipe from which this sample was taken was of the Scotch iron make, which is identified by the bulging rings found on every length; they are from 3 to 4 inches wide, one of which rings can be seen at the left of this section; this make of pipe is further identified by the lengths being 9 feet instead of 12 feet; the hub is also deeper. Subsequent to the bursting of this main at this point, there have been three other failures upon the same pipe in this street, within short distances from each other, due to electrolysis.

The next illustration, Fig. 7, shows a 6-inch pipe, and as you may readily see shows a clear case of electrolysis. This was taken from Wallabout Place, near Washington avenue, a short distance from the canal, and near the power station. This pipe was positive to rails on Washington avenue, positive to canal, and positive to a gas main in same street. The highest reading found was 5.9 volts to rails.

The point about this case is: The main was located near a canal, and when it burst the water flowed away quietly into the canal without showing on the street. It was only by accident that it was finally discovered, when a wheel of a truck passing over this part of the street, which was hollowed out by the force of the water, went down. Then the trouble was found.

The portion at the extreme left end of this sample was where the pipe was found broken apart, so that water, at a pressure of about 45 pounds per square inch from this 6-inch pipe, was being wasted for *nobody knows how long*.

These few practical examples referred to of various movements, and effects of wandering railway currents, may be considered unusual, perhaps remarkable by some; but they are by no means isolated or rare cases. They were selected because illustrating certain movements and effects of which some may not be aware. We trust it will be remembered that similar cases to which we have referred in this paper prevail and must continue to prevail in greater or less degree wherever the single trolley with its ground return is in operation.

In conclusion: We may with profit turn our attention to the question of remedy. The more we gain in experience in investigating piping systems for electrolysis, the more convinced are we that there is but one *cure*, and that is for the electric railways to change their present system of operation to one that is insulated from the earth. This point has been ably set forth in Mr. D. H. Maury's paper, read before this Association, May, 1900.

Two years ago this Association, with no uncertain sound, expressed its opinion upon this question by unanimously adopting the report of the special committee on electrolysis, a report ably and carefully drawn, the gist of which, as you will remember, was a call for the removal of the railway currents from the earth. We cannot better give expression to this action than by quoting a short extract from the editorial columns of *Engineering News*, June 27th, 1901, commenting upon that action, as follows:

"Finally, we wish to give emphasis to the resolutions introduced by the special committee on electrolysis and unanimously adopted by the Association. To that end, we reprint them here, instead of in our report of the meeting. Omitting the preamble, the resolutions are as follows:

Fig. 6.

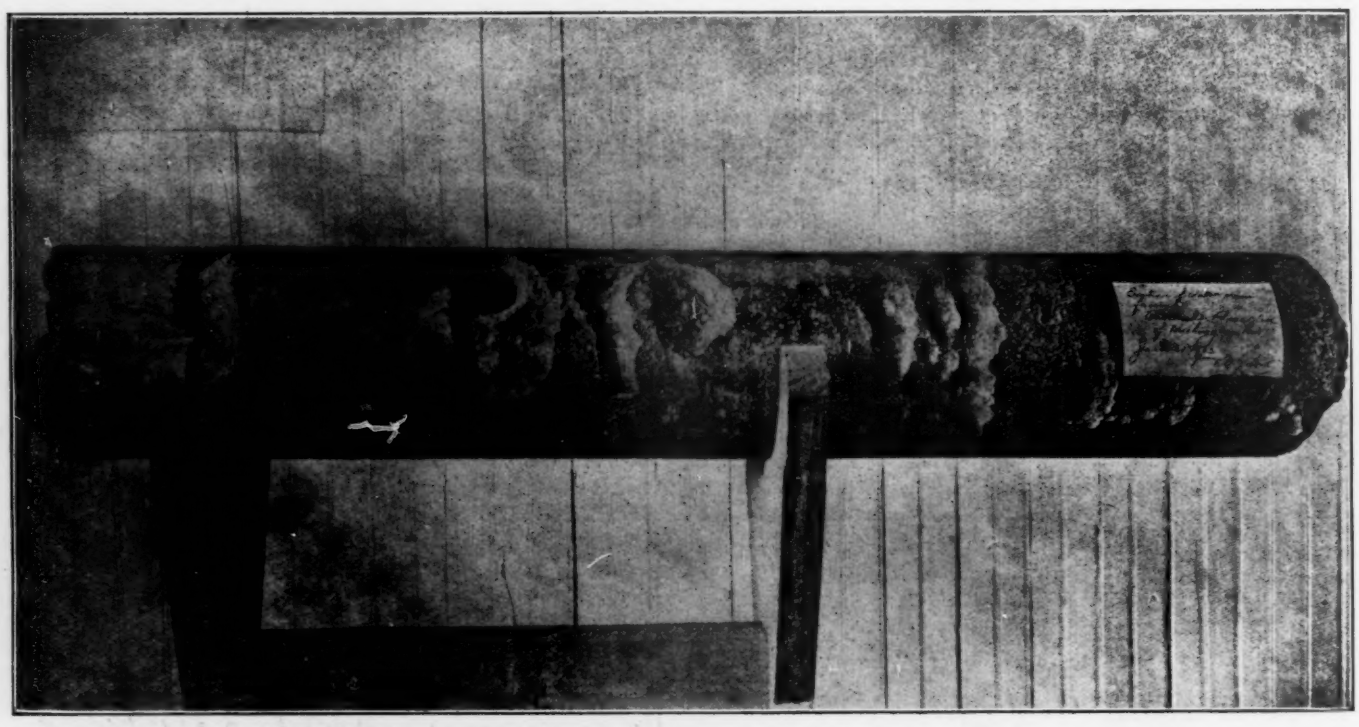


Fig. 7.

* * * Street railways have no right to so operate their cars as to cause injury and destruction to water pipes, and "That street railways now operating under the single trolley system ought to be required to remove their return currents from the ground, and that if they continue to operate by current transmitted from the power station to motors on the cars, they should be required to provide a complete metallic circuit of sufficient capacity to convey all the current, and in a manner to absolutely insulate it from the rails and from the earth. This is clear-cut, dignified and, at least in the end sought, eminently just."

It would appear, therefore, that no mistake was made in the action taken by the Association at that time. So far as the railway companies are concerned, however, in complying with such resolutions, no move seems to have been made on their part. The suggestion is made, therefore, that it may be worth while to again consider the expediency of taking further similar action, with a view of obtaining some permanent relief from the destructive effects of electrolysis.

Coal Gas and Its Mixtures with Carburetted Water Gas for Heating Purposes.

By Thomas Fletcher, F.C.S., in *Gas World.*

A great outcry has been raised by many consumers who are now being supplied with this mixture by their various gas companies as to its inferiority to the coal gas they have been accustomed to. As regards the lighting power, this cannot be questioned, as ample care has been taken by the law and the gas examiners to safeguard the interests of the consumers to the fullest possible extent, and this point, therefore, needs no consideration. Its value for heating and cooking has, however, not been under any such protection; and as an independent observer, without the slightest bias in either direction, the following figures, collected and verified by myself, may safely be taken as both correct and from a totally independent source. Any statements made by the gas companies or given in journals devoted entirely to the extension of the gas industry, if absolutely correct and given by the highest authorities, are liable in

the minds of many householders to be taken as biassed. The matter has been a subject of great interest to myself for many years past, but, as any engineer will know, the necessary tests were practically impossible in my own laboratory, and the only method has been to slowly collect and compare odd independent tests, for which I have to express my thanks to many gas engineers who have given me great and valuable assistance. These were in themselves not sufficiently complete to establish any definite law, but they have served the purpose of proving the correctness of the whole table, for which, in its complete form, I have to express my special indebtedness to one well-known gas engineer, Mr. J. W. Buckley, Assoc. M. Inst. C.E., of Falmouth, who, from the time and care expended, is evidently as fully aware of the importance of the subject as myself.

Boiling Burner, No. 10 *Standard, Fletcher's.*

Tests of time and consumption to boil 4 pints of water by coal gas, carburetted water gas, and different percentages of the two gases.

Gas Used.		Time—Consumption Pressure of Gas, 10-10.		Height of Flame Above Top of Bars. Inches.	Time—Consumption Pressure of Gas, 20-10.		Height of Flame Above Top of Bars. Inches.
Coal Gas.	C. W. Gas.	Time. Minutes.	Consumption Cubic Feet.		Time. Minutes.	Consumption Cubic Feet.	
All		13½	2.30	1½	9¾	2.45	2
Percentage							
90	10	13½	2.30	1	10½	2.45	1¾
80	20	14¼	2.30	1	10½	2.45	1½
75	25	14½	2.30	1	10¾	2.45	1½
50	50	15½	2.40	¾	11¼	2.50	1½
25	75	15¾	2.40	¾	11½	2.50	1¼
	All	16	2.40	½	12½	2.50	1
Boiling Burner, No. 15 *Standard, Fletcher's.*							
All		11	2.35	2	8½	2.65	2½
Percentage							
90	10	11½	2.35	1	8¾	2.70	2
80	20	11½	2.35	1	9	2.70	2
75	25	11¾	2.40	1	9	2.70	2
50	50	12½	2.45	¾	9¼	2.72	1¾
25	75	12½	2.45	¾	9½	2 72	1½
	All	13½	2.46	¾	10	2.75	1¼

Note.—Temperature of water before experimenting, 50° F.
Water at sharp boiling on reading of time and consumption.

There are some points of importance which are indirectly shown and which should not be overlooked.

The kettle used was enamelled steel, 10½ inches diameter on the bottom. Not only is enamel an extremely bad conductor of heat, but the smooth, shiny surface is one of the worst for absorbing it; a copper kettle, the bottom of which has been dulled or slightly blackened with use, would have given a considerably higher duty for the gas consumed.

The pressure of the gas is shown to be an important factor, and should, for the best results, never exceed 10-tenths, *i. e.*, equal to a column of water 1 inch in height. This is the pressure at which the best burners for heating purposes are tested, and is the most usual daylight pressure at which gas is supplied in this country.

The mixtures of the gases in any proportion not exceeding 25 per cent. of carburetted water gas to 75 per cent. of coal gas give all precisely the same duty for heating purposes for the gas consumed, and, therefore, cannot make any difference in the gas bills. If there is any increase the cause must be looked for elsewhere, and, as a rule, it is caused by the increased pressure which the users are frequently asking for, when their gas pipes and fittings, put in in the cheapest possible way, are too small to give a proper supply without an excessive pressure to force the gas through.

Some Facts About Meters and Transformers [1]

It is well known to managers that the poor financial condition of their lighting and power companies is often due to the excessive losses arising from the use of old types of meters and transformers. Such meters run slow after being in use for some time, on account of increased friction in the moving parts, which can usually be traced to heavy moving elements, rough commutators and very often to the dust which, sifting through poorly sealed cases, lodges in the movements. The source of these losses has been recognized and has resulted in many cases in the old apparatus being replaced by that of modern characteristics.

The experience of a station which has made such a change may be recited. The central station referred to is operated by steam power furnishing current for lighting residences and business places, principally the former. During the year 1899 the plant was operated during the night hours only, and there were in service on its circuits 353 transformers and 406 meters, all of old types. The customers were metered.

Being satisfied that the distributing system was very inefficient, the superintendent decided to demonstrate this to the management. There being no primary wattmeters on the switchboard for measuring the total output of the station, no comparison could be made with the amount of current paid for, and he was compelled to arrive at this comparison by a different method. After considering the merits of the various wattmeters on the market he purchased a 10 ampere, 100-volt Westinghouse round pattern wattmeter, which was installed in a residence in series with a 5-ampere meter of the type then commonly in use on the circuits. Before making the test the old type meter was completely overhauled and cleaned.

At the end of 10 days the old meter indicated a consumption of 24 kw. hours and the Westinghouse wattmeter 29.1 kw. hours, a difference of 5.1 kw. hour, or 21.25 per cent. This, at the average rate charged for current at the time, resulted in a loss of 9.16 cents per night on this customer. It should be noted that the old meter had the advantage of being larger and had been thoroughly cleaned just before the test was made. The above test resulted in the purchase and installation of Westinghouse primary wattmeters. During the year 1899, when the old meters and transformers were in use, the station output was as follows:

	January.	July.	Year.
Kilowatt hours generated	36,483	22,376	379,112
Kilowatt hours sold	13,945	5,888	118,992
Per cent. sold	36.8	26.3	31.4
Kilowatt hours generated and 1 kw. hour sold	2.5	3.89	3.19

The above indicates that for the year 1899 3.00 kw. hours were generated for every 1 kw. hour paid for, or, in other words, only 31.4 per cent. of the generated current was paid for, the remainder being lost by the old transformers and inaccurate meters. A revenue of $21,375 was received for the 118,992 kw. hours sold during this year, making an average price of 17.97 cents per kilowatt hour.

The operating expenses of the generating station during the same year, including all labor and material, interest on bonds, taxes, cost of collections, insurance, free lamp renewals, advertising and general expenses were $14,406.25, making an average cost of approximately 3.8 cents per kilowatt hour generated, or 12.15 cents per kilowatt hour sold, leaving an average profit per kilowatt hour sold of 5.82 cents.

It was decided to substitute a few large transformers having the same aggregate capacity as the 353 smaller ones, and to use short secondary distributing systems. By this means current was furnished to a greater number of customers, and the core loss in the transformers was reduced by 22,500 kw. In other words, the capacity of the generating station was increased by an amount equal to the installation of a 22½ kw. generator without any additional expense whatever for generating plant. The old meters were replaced by Westinghouse round pattern wattmeters during the months of April, May and June, 1900. A test of the new meters and transformers was made in July, 1900, to compare with the test made on old meters and transformers in July, 1899. The following is the result:

	July, 1899.	July, 1900.
Kilowatt hours generated	22,376	19,015
Kilowatt hours sold	5,888	8,589

In July, 1900, a 24-hour service was furnished in place of the 12-hour service of the previous year, but notwithstanding this and the fact that additional customers had been secured during the year, the station output decreased for July by 3,361 hours. With the new meters and transformers the company gave 24 hours' service during July, 1900, with a generated amount of 3,361 kw. hours (15 per cent. less than with the old meters and transformers), and at the same time received payment on 2,701 kw. hours, or 46 per cent. more than with the old meters and transformers with a 12-hour service. This resulted in a decreased cost in coal for the month of $53.77, with an increased revenue of $465.19, or a net gain for the month of $518.96.

Below is given a comparative statement of the results obtained for the years 1899 and 1901.

	1899.	1901.
Total kilowatt hours generated	379,112	650,570
Total kilowatt hours sold	118,992	427,567
Kilowatt hours generated to 1 kw. hour sold	3.19	1.52
Per cent. of generated current sold	31.6	65.7

1. *Iron Age.*

	1899.	1901.
Total cost of current generated	$14,406	$27,610
Cost per kilowatt hour generated, cents	3 8	4 24
Cost per kilowatt hour sold, cents	12.135	6.49
Received for current generated	$21,375	$58,534
Number of customers	406	803
Average price received per kilowatt hour, cents	17.97	13.69
Average profit received per kilowatt hour, cents	5.82	7.20

The increased cost per kilowatt hour for generating current in 1901 was due to an increase in the cost of coal and supplies.

The changes in meters and transformers increased the per cent. in 1901 and reduced the cost of the current sold from 12.15 cents per kilowatt hour in 1899, to 6.49 cents in 1901. The average net profit per kilowatt hour sold increased from 5.82 cents in 1899 to 7.2 cents in 1901, although the average price charged to customers had been reduced from 17.97 cents in 1899 to 13.69 cents per kilowatt hour in 1901.

Customers were pleased with the reduced price and the accuracy of the meters, and their number increased from 406 in 1899 to 803 in 1901. This additional business necessitated an increase in generating capacity from 275 to 400 kw.

In 1902 (23 months after installation) 50 of the new round pattern watt meters were tested to ascertain their accuracy. Out of the 50 meters tested it was found that 49 had not deviated from the original callibration—that is, 2 per cent. plus or minus from 2 per cent. of full load to 50 per cent. overload. The other meter was found to run 4 per cent. fast. All meters were operated on the baby filament by a hylo lamp and none of them crept.

It is a curious fact that in purchasing boilers, steam engines and dynamos great weight is laid on the matter of efficiency (which can vary but a few per cent. in the most efficient and inefficient dynamos), nevertheless meters and transformers are purchased almost entirely on price, without regard to their efficiency.

Composite System of Electrical Transmission and Distribution.

[Read by MR. FREDERICK BEDELL, before the Cleveland Electric Club.]

Electrical energy after generation must be delivered economically and in suitable form to the consumer. This delivery is commonly divided into two parts, namely, transmission and distribution, each of which must be efficient and simple.

Distribution should be by such a system that the customers' apparatus —motors or lamps—are connected directly to the distributing wires without the intervention of special contrivances. Again, inasmuch as low voltage receivers are required, it should be possible to gain the advantage of distributing at a higher voltage than that of the receivers. The 3-wire system is widely used, being very efficient in this respect, and should be retained so that new economies will be in addition rather than alternative thereto. Furthermore, should a change of system be contemplated, it should be possible to convert an existing system into the proposed one without great expense or annoyance. The distribution system should be one that can be supplied from any approved generating plant and transmission system; for example, the distribution system should not call for the abondoning of an existing 3-phase or 2-phase primary line.

Transmission should involve the use of only standard apparatus, including transformers and generators. Provision should be made for supplying electricity in a satisfactory form for light and for power; the motor load should not interfere with the lighting service. Copper economy must not be inferior to the 3-phase system.

In a word, to be desirable a transmission and a distribution system must not be inferior in economy, simplicity, flexibility or quality of service to existing systems, while it should be superior in as many of these particulars as possible, and at the same time make use of the same apparatus. Let us see in what way the composite system meets these conditions.

In the days of direct current, 10 amp. plus 10 amp. always just made 20 amp.; 10 volts and 10 volts made 20 volts; all quantities added arithmetically. This was substantially so with single-phase current. But with polyphase current we get the *advantage* of geometrical addition; quantities add in *two dimensions* instead of in one. Take the 3 line conductors of a 3-phase system. Between each pair of wires the voltage is, say, 1,000 volts; we have practically 3 single-phase transmissions at this voltage connected together in delta, and yet nowhere does any voltage exceed the 1,000 volts. The 3 points forming the triangle of voltages are in a *plane* and not in a straight *line*.

A similar advantage arises in transmitting jointly a direct and an alternating current, or alternating currents of two frequencies; *differing currents add as though at right angles.* Thus 10 amp. of direct and 10 amp. of alternating current combine to make 14.14 amp. of composite current. Hence it comes about that a saving in conducting material is effected.

A composite current requires only that amount of copper required by either current separately.

In the case cited, let the resistance of the conductor be unity. The line loss is then 100 watts for either current alone and 200 watts for the composite current, whereas if we had superposed two like currents of 10 amp. each the loss would be 400 watts.

Another fundamental characteristic is that differing currents ignore each other; each is ignorant of the presence of the other. *Each has its own independent line drop unaffected by the other*, The regulation of lamp and motor service may thus be made independent; the severest overload on the motors will not cause the lamps to wink.

These properties point to certain important advantages te be gained by double current transmission.

For primary transmission it is commonly desirable that both of the composite currents be alternating; when desired, however, a direct current may be transmitted over single-phase, 2-phase or 3-phase lines for special purposes, as arc lighting, starting rotaries, etc.

In 2-frequency transmission a variety of composite arrangements is possible, of which I will now describe but one—which we will call the tetrahedral system—on account of interesting and peculiar properties which it possesses and the fact that on account of simplicity and economy it fits the requirements of present practice.

We have seen that the advance from single-phase to polyphase transmission is represented, so-to-speak, by the advance from a line to a plane. Why not proceed further and gain any advantage there may be in using a third dimension in our pictorial representation? This we may do by combining a 2-phase current of one frequency (the e.m.fs of which are represented by two lines A and B, at right angles) with a single-phase current of different frequency, the e.m.f. of which is represented by a line C, at right angles to both A and B. The model illustrates this. Two sticks A and B, each 20 inches long, represent phase A and phase B of the 2-phase e.m.f., each 20,000 volts. The stick C, about 14 inches long, to represent a single-phase voltage of 14,140, connects the middle points of A and B. Each stick is at right angles to the other two. The ends of A and B represent the potentials of the 4-line wires, and it will be seen that the difference of potential between any two wires is 20,000 volts; that is, from one end of A or B to another end of A or B is just 20 inches. This is a 4-wire analogy of the 3-wire, 3-phase system. Systems with more than 4 wires with equal potential difference between wires can be employed extending the same principle, but no models can be made to illustrate them, for more than three dimensions would be required. The tetrahedral system, with two frequencies (2-phase current for power and single-phase for light) meets well present practical requirements. I will show by means of lantern slides some of the ways of obtaining and utilizing the tetrahedral system.

Composite transmission with asynchronous currents, as illustrated in the tetrahedral system, possesses the characteristics which we have noted of copper saving and independence of lamp and motor regulation. I will now call your attention to the unicycle system which has been developed and operated by the writer for obtaining independence of regulation by means of synchronous currents. Although the use of polyphase low-frequency current for power, and single-phase high-frequency current for light is generally looked upon as desirable, there are instances in which the installation of only a single frequency is preferred. Suppose that between the two neutral points of a 4-wire, 2-phase system of say 2,000 volts a single-phase e.m.f. of half value, that is, 1,000 volts of the same frequency, be interposed. At the receiving end the single-phase load is similarly connected; in amount the single-phase load should be one-fourth of the polyphase load to give the same regulation, the voltage of the two being 1,000 and 2,000 respectively. We now get, however, a voltage of 2,236 between certain wires. With the same line copper, the load has been increased from 1 (2-phase) to 1.25 which exactly corresponds to the increase of line voltage. The generator and transformer voltages are the same as before and the single-phase and polyphase load are independent as to regulation. With 1-frequency we are, however, always limited to one plane in our graphical representation of potential difference and must forego the luxury of the third dimension with its accompanying advan-

tages. The unicyclic system may be used advantageously when a station has outgrown the capacity of its primary lines.

The system is particularly suited to transmission lines for both light and power. Take the case of long distance trolley lines supplied through rotaries from polyphase feeders Intermediate towns through which the line passes may be lighted by single-phase current from the same feeders with independent regulation. For secondary distribution the problem usually is to combine a direct current, 3-wire system with an alternating single-phase or polyphase system. This means that the Edison district of a city may be invaded with alternating apparatus—Nernst lamps and induction motors—and that the Edison district itself may be profitably extended into the outskirts of the city hitherto exclusively alternating. This suggests a happy solution of the municipal distribution question.

There are various ways of applying the composite system to such service, and when the use of the system is contemplated a careful study of local conditions will show the best way of adapting the system to each particular case. It is so flexible that I can scarcely give a brief and general description, but from the lantern slides of typical applications of this system, some of which are actual wiring schemes, you will see the practical working of the system.

Some of the arrangements shown have only been tried experimentally. For combining direct and single-phase either generators or receivers, I will show you the square, the interneutral and the plain differential connection. The square connection is convenient for receivers, but not for generators; the reverse is true with the differential connection. The combined square and interneutral connection gives a good working system. With 2-phase alternating current, the square connection cannot be used; either the differential or the interneutral connection may be used to advantage. This gives a very flexible distribution system, supplying incandescent and Nernst lamps, and also direct current and polyphase motors. The copper economy is high. For isolated plants all the current can be supplied by a single double current generator.

I have shown you some of the ways in which the composite system is used for transmission and distribution. The simplicity of the circuits, the saving in copper, the improved regulation and great flexibility of the system are important characteristics, which make it desirable not only for new work but also as a means for development and improvement in the case of transmission and distribution systems now in operation.

Does it Pay to Rush Work?

Engineering News in discussing the problem remarks that we all know that there is a limit to the number of men that can be worked to advantage on any job. Put more men on the work, and they are in one another's way. Take some men off, and the fixed expenses begin to eat up profits. There is always a happy medium that the contractor seeks to maintain, but the happiest medium is not always the one selected by the contractor.

The contractor of experience has learned that it does not pay to invest a great deal of money in a plant suitable only for special work, unless he is assured of a great amount of that work. He knows that paper profits often vanish when such a plant is finally disposed of; for usually it must be sold at a sacrifice. Or, if it is not sold, he is liable to even greater loss in having a large part of his working capital tied up.

For these reasons when the average contractor is awarded a piece of work for which he really should have a larger plant than he possesses, his inclination is to carry the work through by hook or by crook without buying more tools. In a word, he decides to drag the work along somehow, and trust to luck that the penalty clause for non-completion within the time limit will not be enforced. Is this a good business policy? Run over in your mind the contracting firms that are always well spoken of by engineers, and ask yourself what is the chief characteristic of the work done by those firms. Almost without exception you will find their most noticeable policy is the policy of rushing work to a finish. It is true that it costs them a greater sum per cubic yard to get their work done, but it will be observed that somehow they always get more work to do. Those contractors have been students of human nature, as well as of costs, and they have early learned that in the eyes of nine engineers out of ten almost anything is pardonable but slowness.

Now there is usually a very good reason why the engineer is eager to have work rushed, for he in turn is being "pounded on the back." If he is in charge of sewer work or street paving he hears one continuous howl about torn up streets. If he is in charge of railway work the directors of the road are demanding instant completion so that earnings will be available to pay interest on bonds. There is in fact scarcely any class of engineering work, public or private, where some one of influence is not urging the engineer to "hurry it along."

In view of these conditions it is not at all surprising that the reputation of a contractor depends more upon his energy in the execution of work than upon all else.

If looked upon in a broad way it will be seen that, in the end, the energetic contractor is the gainer in more ways than this one of good reputation. It is not alone the profit that is made upon each yard of work that determines success, for that profit must be multiplied by the number of yards handled each working season. Where work is rushed the actual profit on each yard may be small, but due to the great number of yards handled, the total profit will be large. An old and successful contractor said: "I never bite off more than I can chew, but I chew what I bite off fast."

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

A CORRESPONDENT in New Bedford, Mass., writing under date of the 3d inst., says: "The benches of inclined retorts erected on the works of the New Bedford Gas and Edison Light Company by the Connelly Iron Sponge and Governor Company, of New York, were put in service the 8th ult., which fact marks the first manufacture of coal gas in inclined retorts in New England. The plant is reported as working very smooth, the average make per mouthpiece for the past week being well above 20,000 cubic feet per diem, or an average of considerably over 240,000 cubic feet per diem in the two benches of 6's. The plant has a capacity of 750,000 cubic feet per day, and includes coal and coke handling machinery. The New Bedford Company is making other extensive alterations and improvements which, when completed, will enable its owners to say that they are operating one of the best equipped gas works in New England."

MR. JOHN C. LYNCH, the recently appointed Gas Inspector for Omaha, Neb., assumed the duties of that office the 1st inst.

MR. J. A. CORLEY, Superintendent of the Owensboro (Ky.) Gas Light Company since 1887, has resigned. His successor is Mr. J. H. Beatty, of Bowling Green, Ky.

MR. W. P. NYE, Treasurer of the Providence (R. I.) Gas Company, has notified the shareholders that the Company's current quarterly dividend of $1 per share is now payable.

THE authorities of Berkley, Cal., in fixing up their taxing and license schedules for the year, have declared that "Every person, firm, association or corporation supplying gas to more than 100 houses in Berkley must procure a license therefor from the town marshal, and pay for such license the sum of $25 per quarter year."

MR. D. W. CORBETT has resigned the position of Manager and Treasurer of the Orange County Gas and Electric Company, Middletown, N. Y. His successor is Mr. C. B. Buckley, who has served the Company as Cashier and Bookkeeper.

MR. R. N. ANDREWS has been appointed Superintendent of the Hamilton (O.) municipal gas and electric lighting plants.

THE contract for handling the entire coke output of the Cincinnati (O.) Gas and Electric Company has been awarded to the Cincinnati Gas Coke, Coal and Mining Company.

THE Directors of the Grand Rapids (Mich.) Gas Light Company have announced a concession in the selling rate, to take effect October 1st. Under the agreement the gross rate is put at $1.10 per 1,000 cubic feet, with 20 cents off per 1,000 for prompt payment.

A CORRESPONDENT forwards the following from Easton, Pa.: "The stockholders of the Easton Gas Company, Delaware Gas Light Company, Easton Fuel Gas Company, Williams Township Gas Company, Forks Township Gas Company, Palmer Township Gas Company, West Easton Gas Company and the Easton Power Company, have merged all the corporations into one Company, to be known as the Easton Gas and Electric Company. The following officers have been elected by the consolidated Company: President, Chester Snyder; Vice-President, Fred. R. Drake; Secretary, J. W. Fox; Treasurer and General Manager, A. B. Beadle."

THE proprietors of the Quincy (Ills.) Gas and Electric Company have given notice that a "lamp requisition" will have to accompany burned out electric lamps that are to be exchanged for new ones. The orders must be filled out and signed by the party in whose name the account with the Company is held. Blank requisitional orders may be obtained on application at the Company's office. The gas end of the Quincy Company's business shows great increases.

THE gas and electric plants of the Richmond (Ind.) Light, Heat and Power Company have been purchased by Messrs. Bertron & Storrs, of New York.

THE Brookline (Mass.) Gas Light Company, contrary to the surmise of some capitalists in the Massnchusetts "financial 50," has declared the usual quarterly dividend of 2½ per cent. It has been payable since the 1st inst. It is said that the earnings of the concern are sufficient to pay a 3 per cent. dividend for the term, making proper allowance, too, for depreciation and future growth accounts.

THE City Council, of Alliance, O., has authorized the Alliance Gas and Electric Company to charge for an artificial gas supply, for a period of 5 years, the net sum of 90 cents per 1,000 cubic feet, the quality of the gas to be not less than 16 candles, as "determined by the rules" now in vogue for such testing.

THE new plant of the Citizens Gas, Electric and Heating Company, of Mount Vernon, Ills., is completed and in satisfactory working order.

THE Stevens-Forman-Turner-Byllesby syndicate, that recently acquired the gas and electric lighting plants of Centralia, Ills., will rebuild the gas division of the property.

WRITE to Mr. Charles Warren Hunt, Secretary of the American Society of Civil Engineers, for information respecting the rules of award, conditions governing the competition, etc., for the John Fritz Medal. Mr. Hunt's address is 220 West 57th street, New York city.

WE regret to have to chronicle the death of Cora E. Graves, the estimable wife of Mr. George W. Graves, whose demise occurred at her home in Rochester, N. Y., towards the close of last month. Deceased was born in Brockport, N. Y., March 15th, 1847, and was noted for her devotion to the advancing of well-followed methods for the amelioration of the needy in and about Rochester, N. Y.

AS soon as the Board of Gas and Electric Light Commissioners has granted the necessary authority, the Lawrence (Mass.) Gas and Electric Company will extend its mains to and through the outlying district of Andover. The Commissioners were to have considered the petition last Tuesday.

MR. JAS. B. GRIMWOOD, Secretary of the Pacific Coast Gas Association, desires, on behalf of the Library Committee of the Pacific Coast Gas Association, to secure a copy of "King's Treatise." Send replies addressed to him at the Rialto Building, San Erancisco.

THE proprietors of the Williamstown (Mass.) Gas Company—which proprietorship is quite largely centered in the personality of Col. F. S. Richardson, of North Adams, Mass.,—are responsible for the following recent official intimation, for the receipt of which we are indebted to "W. F. A.": "Soon after the middle of August we expect the work, now in progress whereby coal gas can be distributed in Williamstown, will be completed. Herewith is appended a scale of prices for both gas and electricity, the former to take effect when the distribution of the present oil gas is discontinued, the latter beginning with July 1, 1903. Customers will please bear in mind that it requires less of the present high candle oil gas per hour to obtain the same illumination than by other relative means, and that the difference in prices between the two gases is based on that fact. Further reductions will be made whenever an increase in business and reduction in cost of manufacture will permit. The prices offered, however, are now lower than those prevailing in places where the consumption is no larger than in Williamstown: Gas—Less than 15,000 cubic feet per month, $1.80 per 1,000 cubic feet; 15,000 cubic feet, and less than 50,000 cubic feet per month, and for all mechanical and gas stove purposes, $1.60 per 1,000 cubic feet. Electricity—Less than 75,000 watts per month, 15 cents per 1,000 watt hours; 75,000 watts and less than 225,000 watts per month, 14 cents per 1,000 watt hours; 225,000 watts or more per month, 12 cents per 1,000 watt hours; consumption for power, 5½ cents per watt hours. For incandescent lamps by contract a charge of $1.11 per month will be made for each 16-candle power lamp burned until midnight, and where burned all night a 10-candle power lamp will be furnished at the same rate."

THE Citizens Gas Light and Fuel Company and the Taylorville Electric Company, both of Taylorville, Ills., have certified to a consolidation of interests. The capitalization of the succeeding concern, which is to be known as the Taylorville Gas and Electric Company, is put at $85,000.

THE Devonian Gas Company has been formed in Jersey City, N. J., for the purpose of "manufacturing gas from crude petroleum," or from "the sludge oil from refineries." The concern is capitalized in $100,000, but the incorporators reserve the right to increase the same to $1,000,000—it looks to us they will need more than the maximum sum before they are doing business satisfactorily on the sludge oil basis. However, the names of the trying incorporators are W. Monde Greene, Frank A. Van Winkle and Clarence A. Walker.

THE Louisville (Ky.) Gas Company has been put on a 6 per cent. per annum basis, the last dividend (current month) being at the rate of 3 per cent. for the half year.

A CORRESPONDENT in Cleveland, O., forwards the following: "In the death of Jesse Healy Morley which happened quite unexpectedly the morning of June 21st, Cleveland lost one of its oldest and best known citizens. At the time of his death Mr. Morley was in his 84th year. He was born May 15, 1820, in Brutus, N. Y., and was the eldest son of Esther Healy and Albert Morley. In 1832 he came to Painesville, O., and worked in the store of his uncle, Louis Morley. Six years later, in 1838, he became a partner in the firm of A. & W. Morley, the firm name being changed in 1841 to A. Morley & Son. Mr. Morley came to Cleveland in 1847, and entered into a partnership with H. K. Reynolds, under the firm name of Morley & Reynolds. The hardware stock and business of J. F. Kirtland was purchased by the new firm, in which Mr. Morley retained his interest until 1856, when he sold out to his partner. In 1862 the firm of Morley & Cary was formed, the partners being Mr. Morley and Mr. John G. Cary. This firm corroded lead by what was known as the quick process. The firm of J. H. Morley & Co. was established in 1865 by J. H. Morley and T. H. Beckwith. This firm manufactured lead by the old Dutch process, and continued in business until 1887, when it became the J. H. Morley Company, a branch of the National Lead Company. Mr. Morley became a stockholder and Director of the Cleveland Gas Light and Coke Company in 1852. He was President of the Company from 1883 to 1895, and Vice-President at the time of his death. Mr. Morley was prominently identified with many of the best business and financial institutions of the city, and was recognized as a man of rare business judgment and ability. His extensive business ventures brought him into contact with financial leaders all over the country, and the news of his death will cause widespread and sincere regret. His sterling integrity and his splendid character won for him the esteem of all who came within the range of his influence. In 1858 Mr. Morley married Miss Helen Marshall Rockwell. She and their two children. Mrs. Mitchell Kenerley, of New York city, and Mr. Charles Rockwell Morley, of Cleveland, survive him.

MR. JOHN HOBAN, for almost half a century connected with the office division of the Cincinnati Gas Light and Coke Company, died at his home in that city the afternoon of the 3d inst. He was in his 71st year.

MR. JAMES WILKINSON, for many years superintendent of Works, Washington (D. C.) Gas Light Company, died in the University Hospital, Washington, the evening of the 4th inst. He was born in Philadelphia, October 21st, 1828, and became a resident of Washington in 1863, connecting himself with the Washington Company later on in a subordinate capacity, and eventually going on to the post of works' superintendent.

THE Town Council of Hampton, Va., is considering the advisability of asking for bids for the construction at that point of a combined gas and electric lighting plant.

THE Massachusetts Board of Gas and Electric Light Commissioners has agreed to the petition of the Suburban Gas and Electric Company for permission to increase its capital stock in the sum of $175,000. The stipulation is made that the new stock shall be issued to owners of record at the rate of $110 per share.

THE AMERICAN GAS LIGHT JOURNAL

A. M. CALLENDER & CO.,
PROPRIETORS.

THOS. J. CUNNINGHAM,
ELBERT P. CALLENDER,
EDITORS.

CHAS. E. SANDERSON,
MANAGER.

PUBLISHED ON EACH MONDAY OF THE YEAR AT
No. 42 Pine Street, New York.
Telephone, 2996 John.

TERMS:

SUBSCRIPTION -Three Dollars per annum, in advance. Single copies, 10 Cents.

The JOURNAL is the official organ of the
NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
AMERICAN GAS LIGHT ASSOCIATION.
WESTERN GAS ASSOCIATION.
OHIO GAS LIGHT ASSOCIATION.

NOTIFICATION RESPECTING ADVERTISING.

Orders for new advertising, or for changes in standing advertisements, to insure attention in the issue following their reception, must be in hand any time of Wednesday.

AGENTS:
New York—American News Co., 39 and 41 Chambers St.
Germany—Lemcke & Buechner, of New York.
England—Aug. Siegle, 30 Lime Street, London.

MONDAY, JULY 13, 1903.

The Market for Gas Securities.

There was considerable trading in Consolidated gas during the week, no less than 5,600 shares having been sold on the Exchange today (Friday), and the bulk of the trading was effected at lower prices than have prevailed in it for some time past. The low point of 188½ was reached, and the closing sale was 190.

Brooklyn Union was dealt in, to the extent of one lot of 400 shares, at 205, which quotation is 7 points lower than the last prior recorded sale. Peoples, of Chicago, remained steady. There is absolutely no good reason for the slump in either Consolidated or Brooklyn Union, the values in which, according to the stock exchange quotations, are affected by the operators for the short side. Out-of-town gas shares show no particular change, and the demand for gas bonds is well maintained. The stock of the Louisville (Ky.) Company has been placed on a 6 per cent. basis, and the scrip of the Washington Company is bid at the equivalent of 125.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

16 WALL STREET, NEW YORK CITY.

JULY 13.

☞All communications will receive particular attention.

☞The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$73,177,000	100	190½	191
Central Union, Bonds, 5's.	3,000,000	1,000	109	111
Equitable Bonds, 6's	1,000,000	1,000	105	..
" 1st Con. 5's	2,300,000	1,000	118	120
Metropolitan Bonds	658,000	..	108	112
Mutual	3,500,000	100	290	315
Municipal Bonds	750,000	..	..	..
New Amsterdam Gas Co. ..				
Bonds, 5's	11,000,000	1,000	107½	108
Northern Union, Bonds, 5's.	1,250,000	1,000	106	107
New York and East River ..				
Bonds 1st 5's	3,500,000	1,000	110	113
" 1st Con. 5's	1,500,000	.	109	111
Standard	5,000,000	100	131	..
Preferred	5,000,000	100	132½	..
Bonds, 1st Mortgage, 5's	1,500,000	1,000	115½	118
Yonkers	299,650	500	130	.
Out-of-Town Companies.				
Brooklyn Union	15,000,000	100	205	212
" " Bonds (5's)	15 000,000	1,000	119	119½
Bay State	50,000,000	50	¼	⅝
" Income Bonds	2,000,000	1,000	..	75
Binghamton Gas Works....	450,000	100	28	30
" 1st Mtg. 5's	509,000	1,000	93	96
Boston United Gas Co.—				
1st Series S. F. Trust....	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47½	50
Buffalo City Gas Co.	5,500,000	100	7	10
" " Bonds, 5's	5,256,000	1,000	73	76
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Central, San Francisco	1,900,000	..	106	108
Chicago Gas Co. Guaranteed Gold Bonds	7,650,000	1,000	104	104¼
Cincinnati Gas & Elec. Co..	29,500,000	100	96½	97
Columbus (O.) Gas Co., 1st Mortgage Bonds	1,500,000	1,000	101	101½
Columbus (O.) Gas Lt. & Heating Co	1,682,750	100	88¼	89¼
Preferred	3,026,500	100	107½	109
Consumers, Jersey City Bonds	600,000	1,000	100	102
Consumers, Toronto	1,700,000	50	218	225
Consolidated, Baltimore...	11,000,000	100	57	67¼
Mortgage, 6's	3,600,000	..	..	118
Chesapeake, 1st 6's.	1,000,000	..	..	..
Equitable, 1st 6's.	910,000	..	..	..
Consolidated, 1st 5's....	1,490 000	..	..	112
Consolidated Gas Co. of N.J.	1,000,000	100	15	17
" Con. Mtg. 5's	880,000	1,000	85	87
Consolidated G. & E. Co.'s.				
Little Falls, N.Y.	90,000	100		100
Bonds	75,000	..	..	100
Detroit City Gas Co	4,825,500	50	..	89
" Prior Lien 5's	5,603,000	1,000	99¼	100
Detroit Gas Co., 5's....	981,000	1,000	77	79
" Inc. 5's	16,000	100	98½	100
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Essex and Hudson Gas Co.	6,500,000	..	39	40
Fort Wayne	2,000,000	..	..	..
" Bonds	2,000,000	..	55	..
Grand Rapids Gas Lt. Co. 1st Mtg. 5's	1,225,000	1,000	104½	105
Hartford	750,000	25	245	265
Hudson County Gas Co., of New Jersey	10,500,000	..	25	..
" Bonds, 5's	10,500,000	..	101	103
Indianapolis	2,000,000	..	60	70
" Bonds, 6's	2,650,000	..	102½	105
Jackson Gas Co	250,000	50	73	75
" 1st Mtg. 5's	290,000	1,000	101	102½
Kansas City Gas Light Co., of Missouri	5,000,000	100	..	36
Bonds, 1st 5's	3,822,000	1,000	102	104
Laclede, St. Louis	10,000,000	100	..	.
Preferred	2,500,000	100	92½	..
Bonds	10,000,000	1,000	109½	110
Lafayette Gas Co., Ind.	1,000,000	100		60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	130	140
Madison Gas & Elec. Co.				
" 1st Mtg. 6's	350,000	1,000	107½	108¼
" 6 per cent. scrip, due 1910	100,000	25	85	87
Montreal, Canada	2,000,000	100	218	184¾
Nashville Gas Lt. Co	1,000,000	100	110	..
Newark, N. J., Con. Gas Co	6,000,000	..	56	58
Bonds, 6's	4,600,000	..	105	105¾
New Haven	1,000,000	25	300	325
Oakland, Cal.	2,000,000	..	46	47
" Bonds	750,000	..	..	.
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	97¼	97½
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage....	20,100,000	1,000	..	..
2d "	2,500,000	1,000	104	
Rochester Gas & Elec. Co..	2,150,000	50	85	..
Preferred	2,150,000	50	118	..
Consolidated 5's	2,000,000	..	87¾	90
San Francisco, Cal.	10,000,000	100	51¼	52
St. Joseph Gas Co.				
" 1st Mtg. 5's	751,000	1,000	95	96¼
St. Paul Gas Light Co.	1,500,000	100	45	47
1st Mortgage 6's.	650,000	1,000	113	116
Extension, 6's	600,000	1,000	112½	115
General Mortgage, 5's..	2,465,000	1,000	92	93
Syracuse, N. Y.	1,975,000	100	46	48
Bonds	2,047.000	1,000	98½	99½
Washington, D. C	2,600,000	20	315	325
First mortgage 6's	600,000	..	..	..
Western, Milwaukee.				
Bonds, 5's	4,000,000	..	109½	110
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DIVIDEND NOTICE.

OFFICE OF THE UNITED GAS IMPROVEMENT CO.,
N. W. CORNER BROAD AND ARCH STS.,
PHILADELPHIA, PA., June 8, 1903.

The Directors have this day declared a quarterly dividend of 2 per cent. (one dollar per share), payable July 15th, 1903, to stockholders of record at the close of business, June 30, 1903. Checks will be mailed.

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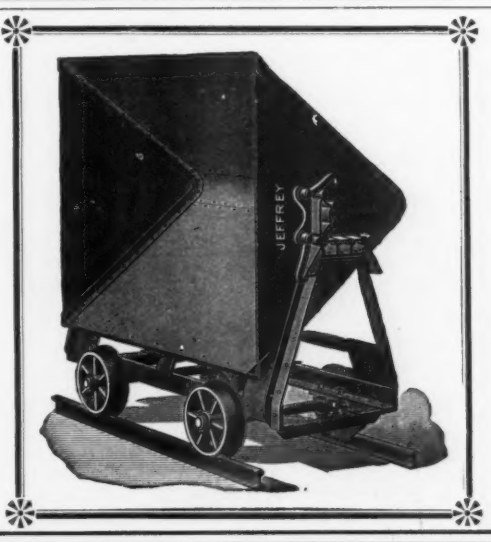

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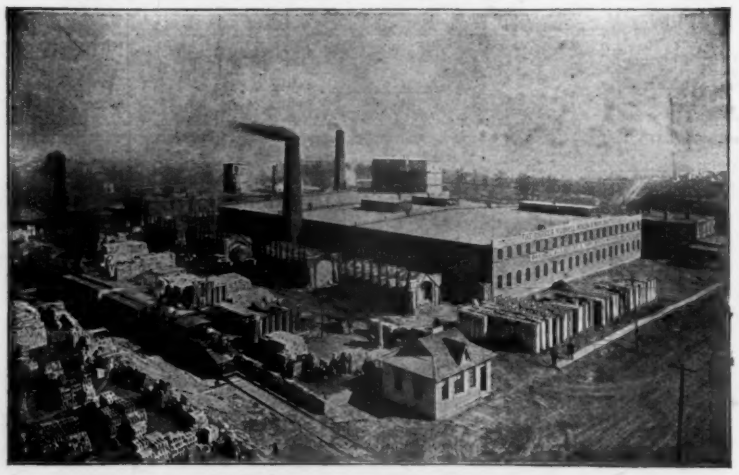

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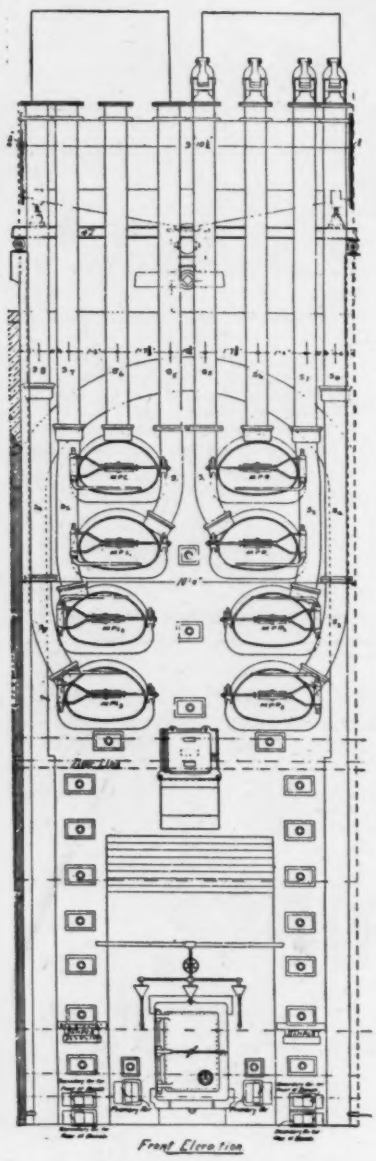

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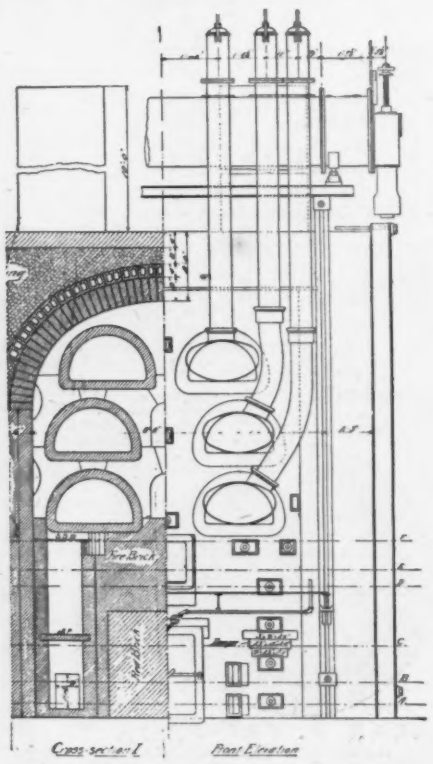

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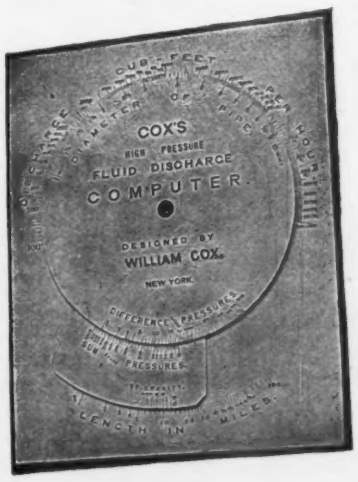

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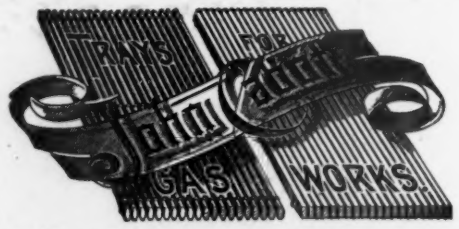

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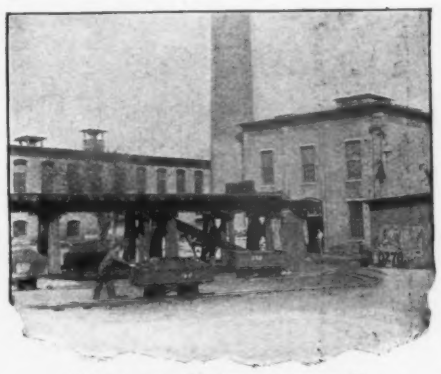

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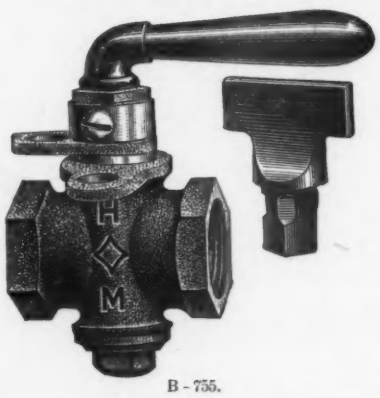

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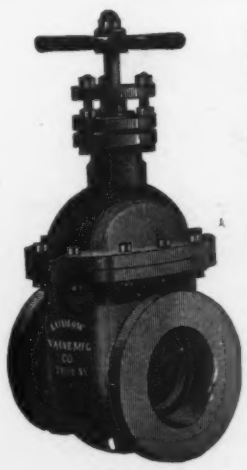

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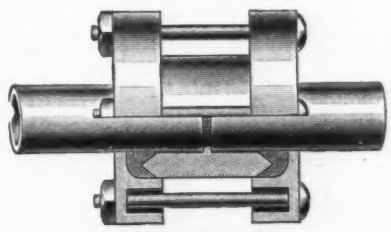

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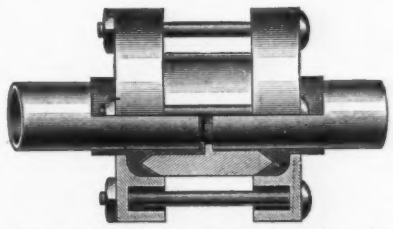

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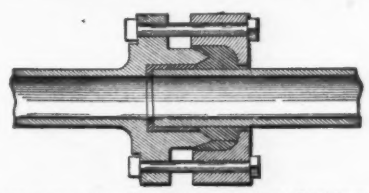

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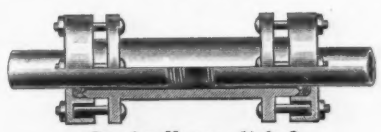

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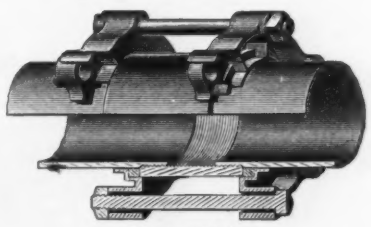

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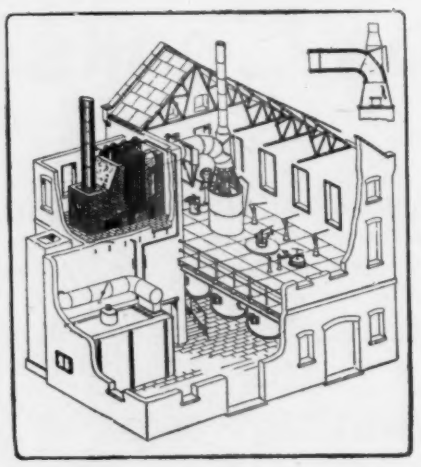

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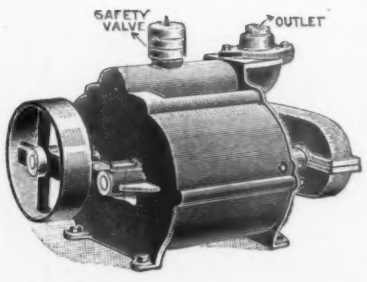

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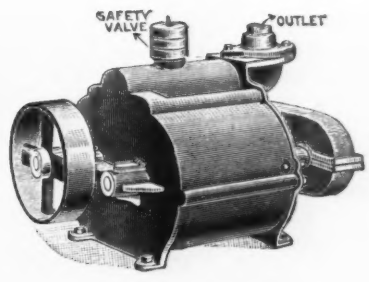

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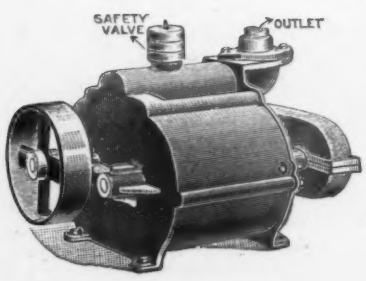

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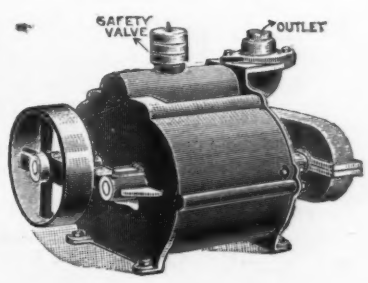

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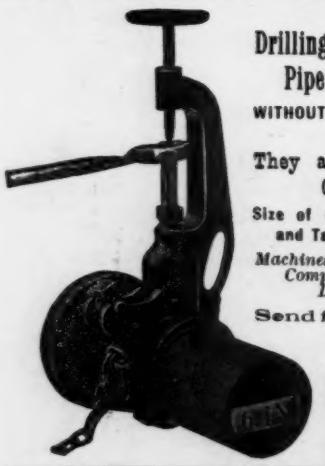

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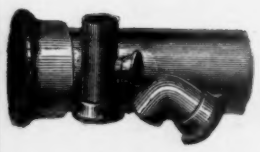

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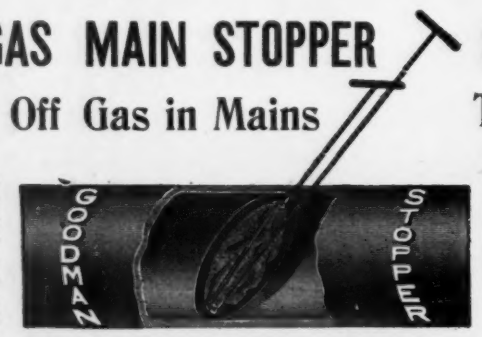

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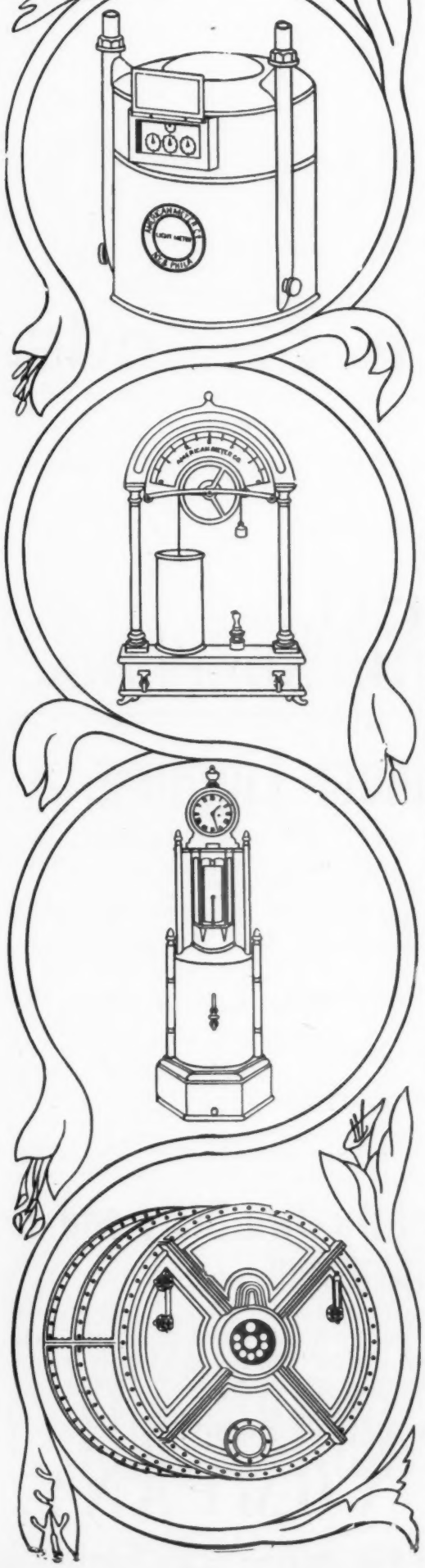

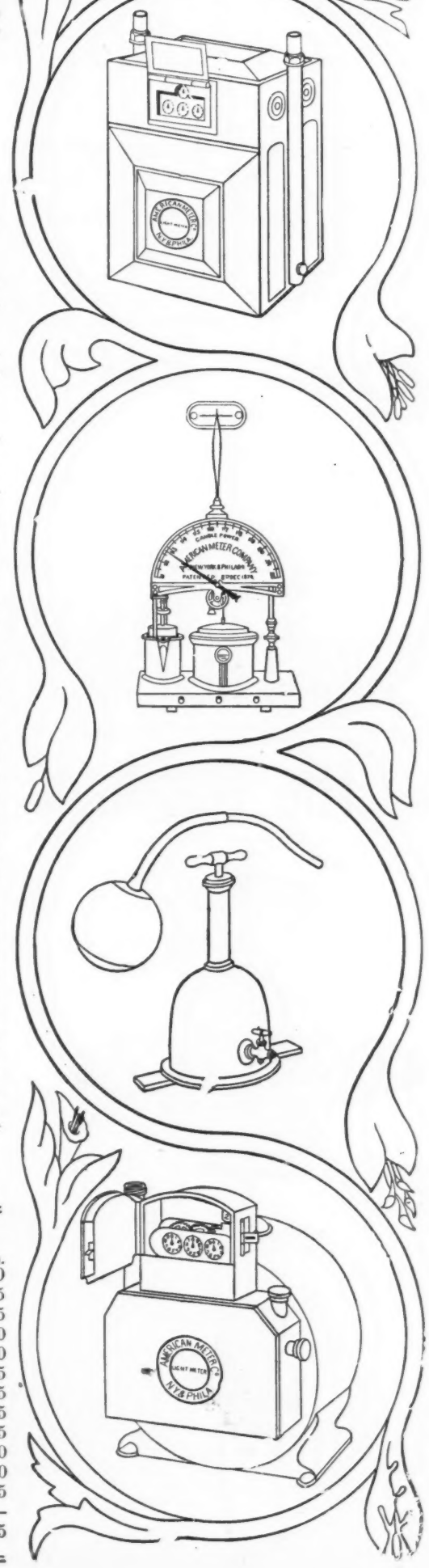

PUBLIC LIGHTING TABLE.

AUGUST, 1903.

Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish.	Table No. 2. New York City. All Night Lighting. Light.	Table No. 2. New York City. All Night Lighting. Extinguish.
				P.M.	A.M.
Sat.	1	11.20 PM	3.50 AM	7.10	3.30
Sun.	2	12.10 AM	4.00	7.10	3.30
Mon.	3	1.00	4.00	7.10	3.30
Tue.	4	1.40	4.00	7.10	3.30
Wed.	5	2.30	4.00	7.10	3.30
Thu.	6	No L.	No L.	7.10	3.45
Fri.	7	No L. FM	No L.	7.10	3.45
Sat.	8	No L.	No L.	7.10	3 45
Sun.	9	7.30 PM	8.40 PM	7.10	3.45
Mon.	10	7.30	9.10	7.10	3.45
Tue.	11	7.30	9.40	7.10	3.45
Wed.	12	7.30	10.10	7.10	3.45
Thu.	13	7.30	10.40	6.55	4.00
Fri.	14	7.30	11.20	6.55	4.00
Sat.	15	7.30 LQ	11.50	6.55	4.00
Sun.	16	7.20	12.40 AM	6.55	4.00
Mon.	17	7.20	1.30	6.55	4.00
Tue.	18	7.20	2.30	6.55	4.00
Wed.	19	7.20	4.10	6.55	4.00
Thu.	20	7.20	4.10	6.45	4.10
Fri.	21	7.20	4.10	6.45	4.10
Sat.	22	7.20 NM	4.10	6.45	4.10
Sun.	23	7.10	4.20	6.45	4.10
Mon.	24	7.10	4.20	6.45	4.10
Tue.	25	7.10	4.20	6.45	4.10
Wed.	26	7.10	4.20	6.45	4.10
Thu.	27	8 40	4.20	6.30	4.20
Fri.	28	9.20	4.20	6.30	4.20
Sat.	29	10.00 FQ	4.20	6.30	4.20
Sun.	30	10.50	4.30	6.30	4.20
Mon.	31	11 40	4.30	6.30	4 20

TOTAL HOURS LIGHTING DURING 1903.

By Table No. 1.	Hrs.Min.	By Table No. 2.	Hrs.Min.
January	245.00	January	423.20
February	192.00	February	355.25
March	201.00	March	355.35
April	167.20	April	298.50
May	152.00	May	264.50
June	131.00	June	234.25
July	140.40	July	243.45
August	156.20	August	280.25
September	171.20	September	321.15
October	198.20	October	374.30
November	216.30	November	401.40
December	232.10	December	433.45
Total, yr.	2203.40	Total, yr.	3987.45

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The cut tells the story—but not all of it. Get one lamp and light it—then the tale's told from beginning to end. For one Welsbach Gas Arc Lamp is a better salesman than 20 pages of advertising.

Here's what it would show if you give it a chance to prove its worth:

1. A mechanical construction and finish that insures the greatest durability.
2. The renewal of mantles and the cleaning of globes without removal of globe.
3. The greatest amount of candle power with least consumption of gas.
4. A by-pass cock so constructed as to permit all or only one mantle burning at a time.
5. A pilot light that consumes but 1 foot of gas in 24 hours. Costs $\frac{1}{10}$ of a cent a day.

Give it a Chance to Tell its Own Story and it Won't Disappoint.

Let us send you one lamp—doesn't cost a fortune—and it will answer every question you put to it; make good on every test given it. You know the only proof of the pudding? What's the use in a fellow telling you it tastes good? Taste it yourself, then you know.

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Winsted, Conn.	Washington, D. C.	Cicero, Ills.
Canon City, Col.	Boone, Ia.	Chicago (Ogden Co.)
Schenectady, N. Y.	Pueblo, Col.	Easton, Pa.
Hagerstown, Md.	Charlotte, N. C.	Lawrence, Mass.
Malden, Mass.	Fall River, Mass.	Council Bluffs, Ia.
Bridgeport, Conn.	Duluth, Minn.	Chattanooga, Tenn.
Albert Lea, Minn.	New York (Mutual Co.)	

TOTAL SETS TO JULY 1, 1903, ... 51
TOTAL DAILY CAPACITY, ... 55,150,000 cubic feet.
TOTAL SETS TO DATE, ... 498
TOTAL DAILY CAPACITY, ... 354,830,000 cubic feet.

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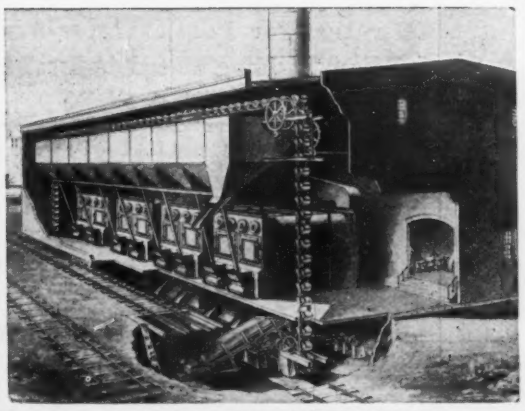

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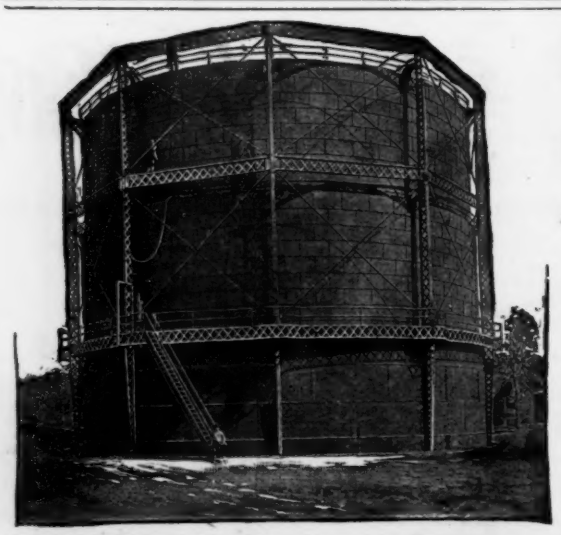

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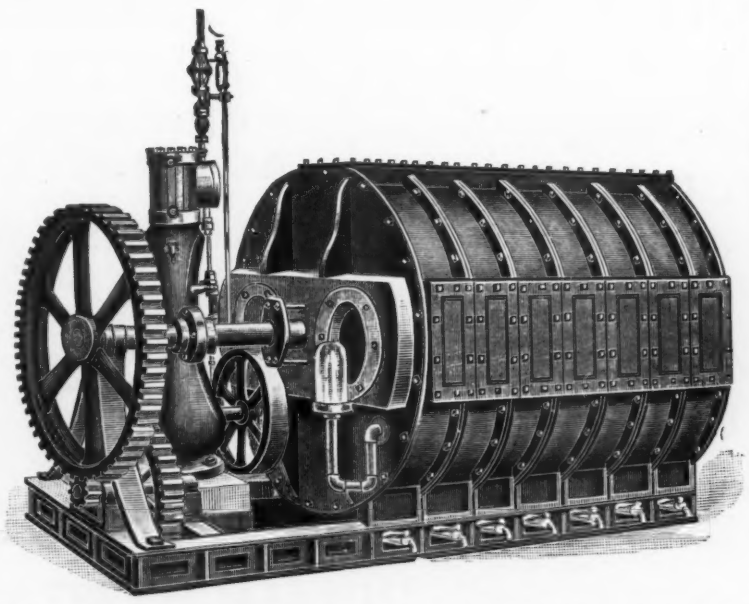

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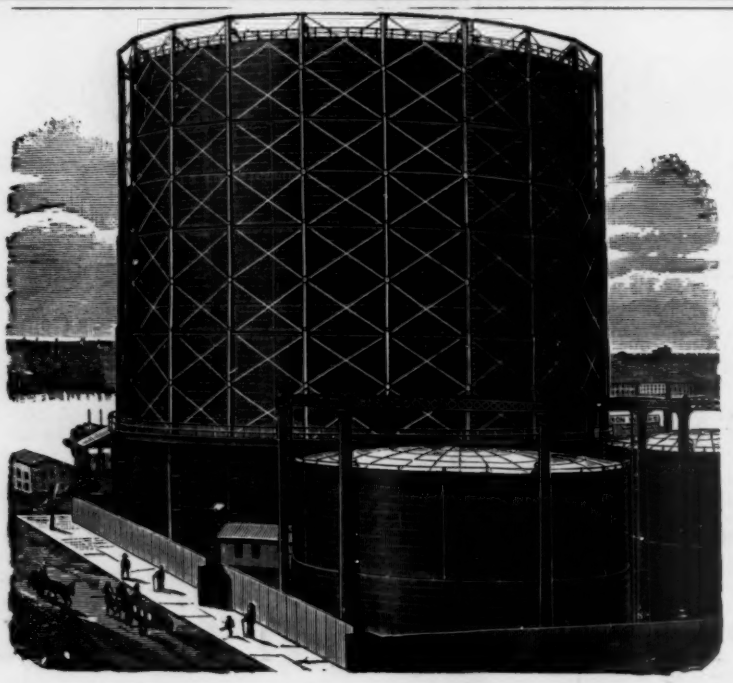

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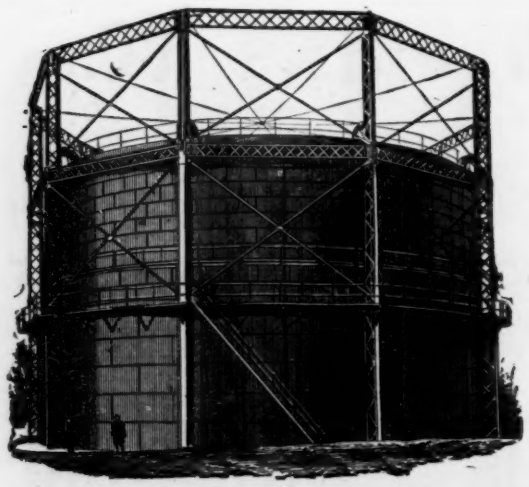

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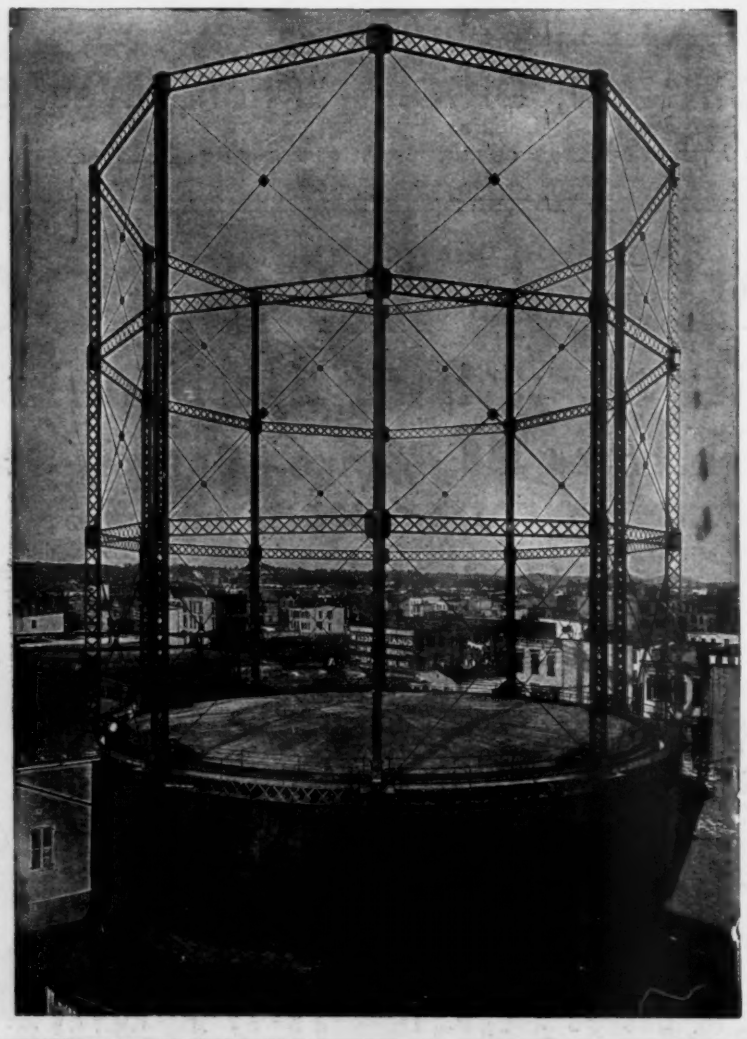

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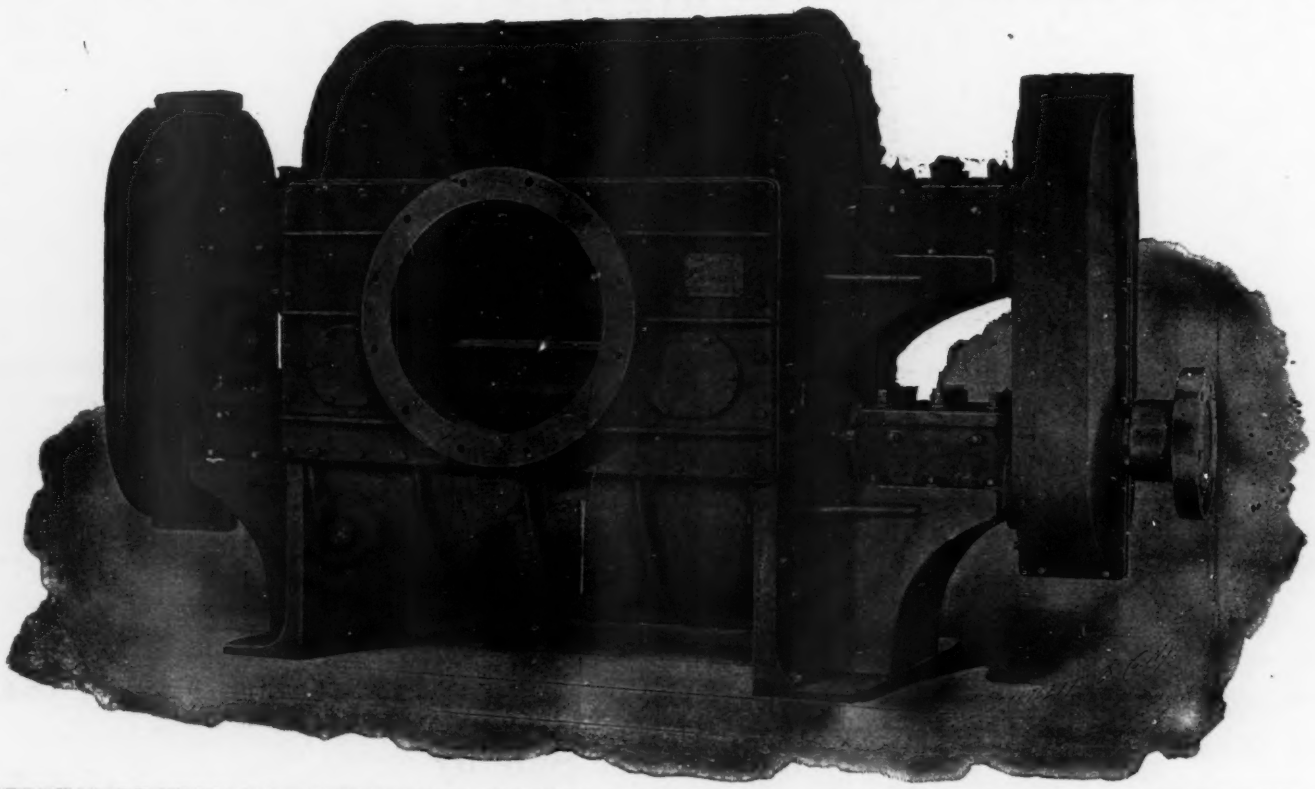

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